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NATIONAL DAM SAFETY PROGRAM. SILVER LAKE DAM. DE0031. DELAWARE --ETC(U)
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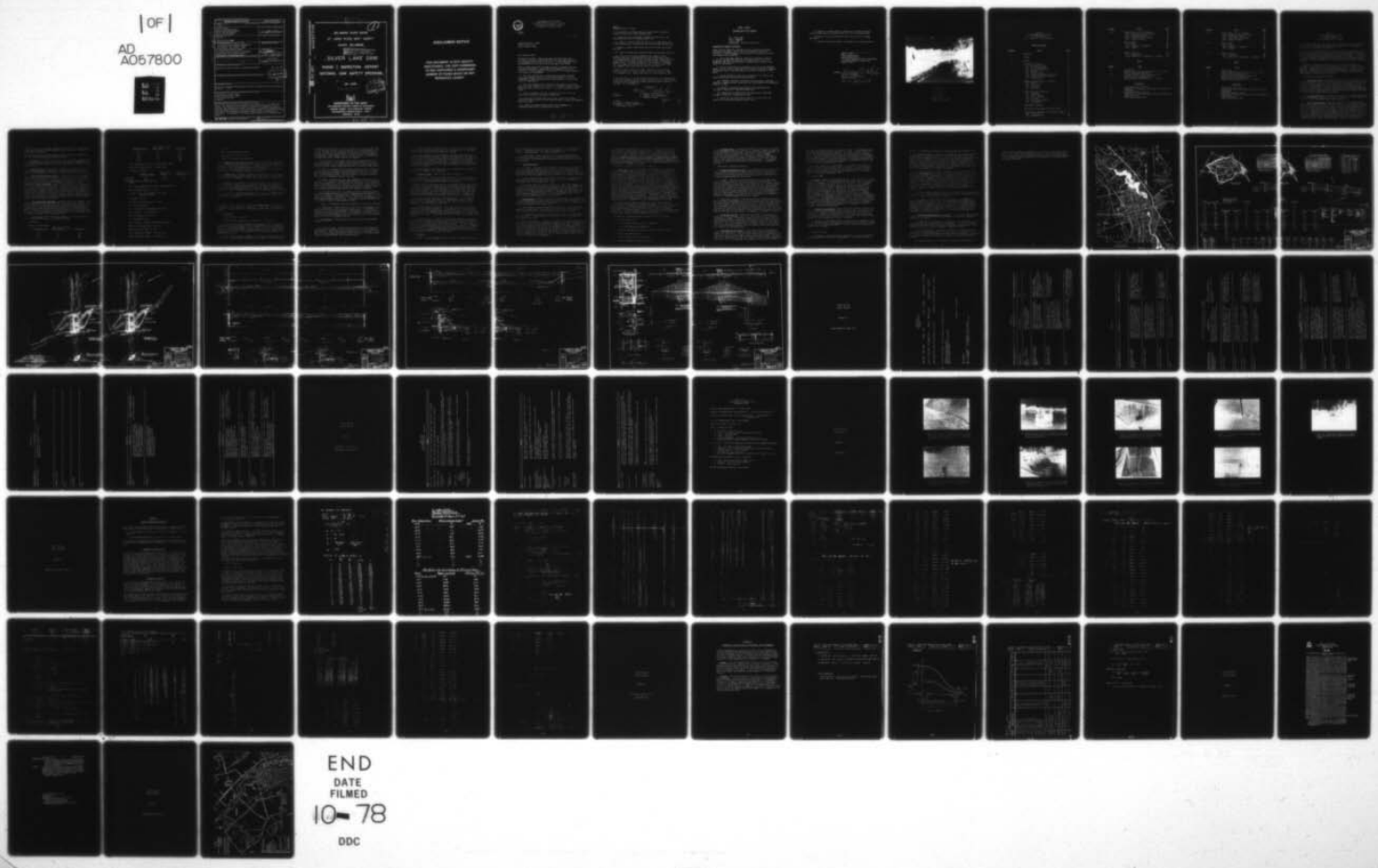

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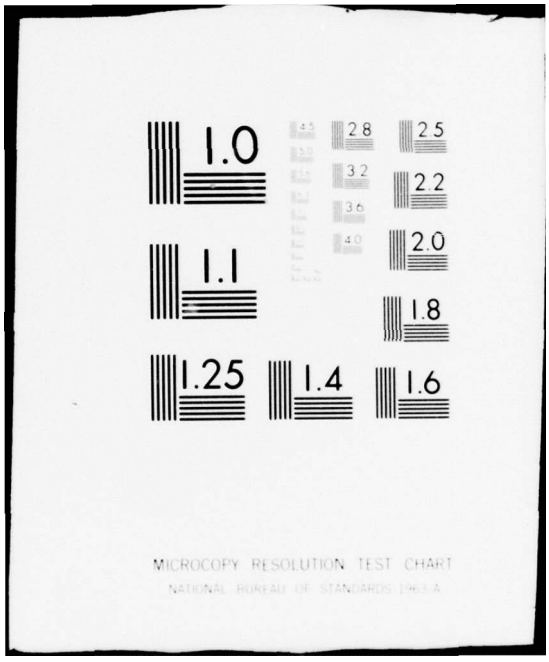
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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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3. RECIPIENT'S CATALOG NUMBER	
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9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Engineer District Philadelphia, Custom House, 2d & Chesnut Streets, Philadelphia, Pennsylvania 19106	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

National Dam Safety Program
Dam Inspection Report Phase I
Silver Lake Dam, Del.
Dams-Del.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

DELAWARE RIVER BASIN

ST. JONES RIVER, KENT COUNTY

DOVER DELAWARE.

SILVER LAKE DAM.

PHASE I INSPECTION REPORT.

NATIONAL DAM SAFETY PROGRAM.

Frank N. Ninci

DE 0031

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106
JANUARY 1978

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PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

21 JUL 1978

Honorable Pierre S. DuPont
Governor of Delaware
Dover, Delaware 19901

Dear Governor DuPont:

Inclosed is the Phase I Inspection Report for Silver Lake Dam in Kent County, Delaware which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first two pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Silver Lake Dam is judged to be in fair condition. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. Due to the small number of inhabitable structures downstream of the dam, together with less than excessive economic loss, it is recommended the dam's hazard potential classification be changed from "high" to "significant."

b. Due to the potential of overtopping of the dam by the 100-year storm, the owner should develop and utilize a detailed emergency operation and warning system within three months of the date of approval of this report.

c. Within six months of the date of approval of this report, the owner should perform the following remedial work:

(1) Placement of suitably sized stone slope protection (rip-rap), including a bedding (filter) course along the eroded upstream and downstream areas of the dam.

(2) Removal of trees and brush from the dam's embankment and replacement thereof with a suitable ground cover.

(3) Installation of safety fencing at the spillway to preclude accidents to the public using adjacent areas.

d. Within one year of the date of approval of this report, the owner should perform the following remedial work:

(1) Repair of concrete spalls and popouts in the overflow section of the spillway and at the upstream ends of the spillway abutment walls.

(2) Repair or replace deteriorated reinforced concrete foot bridge and piers.

(3) Install trashrack and replace staff gage at the intake structure.

A copy of the report is being furnished to Mr. Austin P. Olney, Delaware Department of Natural Resources and Environmental Control, the designated State Office contact for this Program. Within five days of the date of this letter, a copy will also be sent to Congressman Thomas B. Evans. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

Harry V. Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Cy Furn:
Mr. Austin P. Olney, Secretary
Department of Natural Resources and
Environmental Control

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

DAM: Silver Lake
State: Delaware
County: Kent
Coordinates: 39° 10.1'N, 75° 31.4'E

ASSESSMENT OF GENERAL CONDITIONS

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FRANK W. VINCI
Chief, Design Branch
Engineering Division
U. S. Army Engineer District, Philadelphia
Professional Engineer Registration
Maine No. 1897

APPROVED: Harry V. Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE: 21 July 1978

OVERVIEW PHOTO

SILVER LAKE DAM

VIEW LOOKING WEST
FROM
UPSTREAM OF LEFT ABUTMENT
TOWARD RIGHT ABUTMENT

PHASE ONE
NATIONAL DAM SAFETY PROGRAM
SILVER LAKE DAM
ST. JONES RIVER, DOVER, DELAWARE

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PLATES

APPENDICES

PHASE ONE
NATIONAL DAM SAFETY PROGRAM
SILVER LAKE DAM
ST. JONES RIVER, DOVER, DELAWARE

1. AUTHORITY. This report has been prepared in accordance with the National Dam Inspection Act, Public Law 92-367, 92nd Congress, H.R. 15951 enacted 8 August 1972, copy inclosed in Appendix F.

2. PURPOSE. This report assesses the general condition of Silver Lake, with respect to safety of the project based upon available data and visual inspection, determines the need for emergency measures, and determines if additional studies, investigation, and analysis are necessary and warranted. In addition, the report evaluates the hydraulic and hydrologic capabilities and structural stability of the project based on the visual inspection and available engineering data.

3. GENERAL. The Phase One inspection of Silver Lake was conducted on 13 December 1977 by members of the Philadelphia District, U.S. Army Corps of Engineers. Team members included representatives disciplined in the fields of hydrologic, hydraulic, soils and structural engineering. In addition, representatives of the owner, City of Dover, were in attendance and contributed local knowledge and history of the project.

4. DESCRIPTION OF PROJECT AND LOCATION.

a. Description of Dam - The Silver Lake Dam consists of an earth embankment, approximately 18 feet high and 820 feet long with an uncontrolled concrete overflow structure located on the St. Jones River approximately 13.2 miles upstream from the confluence with the Delaware Bay. The overflow structure consists of an ogee-shaped reinforced concrete gravity spillway approximately 13 feet high and 150 feet in length. Drawdown of the reservoir is accomplished by release through a manually-operated sluice-gated 24-inch diameter cast iron pipe through the concrete overflow structure.

b. Size Classification - Silver Lake is classified as a small dam based on a normal impoundment at overflow crest of 580 acre-feet and a top of embankment height of 18 feet above downstream streambed elevation.

c. Hazard Classification - The hazard potential of Silver Lake was considered high during the initial inventory phase of the dam inspection program due to its proximity to the City of Dover. During the inspection, it was noted that few habitable structures exist within the flood plain downstream of the project and that economic loss, in the event of a project failure, would not be excessive. Examination of the flood hazard boundary map prepared by the U.S. Department of Housing and Urban Development for the City of Dover, copy inclosed in Appendix G, and visual on-site inspection indicates that the majority of floodplain downstream of the project site consists of parkland which, if inundated, would not suffer excessive damage. Several restrictions, most

notably the Division Street and Lockerman Street bridges, would cause backup during excessive runoff, thereby preventing any "instananeous" rise in flow downstream of the bridges.

The inspection members recommend the hazard classification be revised from high to significant based upon the above findings.

d. Ownership - The Silver Lake project is owned, operated, and maintained by the City of Dover. Within the city structure, primary responsibility for the operation and maintenance of the project rests with the Parks and Engineering Departments.

e. Purposes of Dam - Silver Lake is presently a single-purpose project operated and maintained for recreation. Boating, water-skiing, fishing, swimming and picnicking facilities are available within the project boundaries.

f. Design and Construction History - The initial Silver Lake Dam was constructed prior to 1900 to provide water for a millrace located at the left abutment of the original dam. During 1943, the original concrete overflow structure failed and plans for reconstructing the overflow structure and filling the former millrace location were prepared by Albright and Friel, Philadelphia, Pennsylvania, under contract to the City of Dover. The construction plans indicate that five alternate construction schemes were made available to the prospective bidders. Four of the options (A, B, C, and E) involved reconstruction of slightly different gravity overflow structures in the original overflow location whereas option D involved reconstruction of the overflow structure in the vicinity of the right abutment. Review of as-built reinforcing drawings and inspection of the existing structure indicates that the contractor, George & Lynch Contractors of Wilmington, Delaware, selected Option C and the reconstruction was accomplished in 1944.

g. Normal Operational Procedure - No formal operational procedures, either normal or emergency, have been established for the Silver Lake project. The uncontrolled overflow structure, which was originally designed to allow the use of flashboards to raise the reservoir pool above overflow crest elevation, is presently unregulated, thereby allowing discharge of all available reservoir inflow. However, the reservoir is reportedly lowered about one foot by use of the 24-inch diameter discharge pipe on an annual basis to allow adjacent property owners to maintain their docking facilities.

h. Pertinent Data - The following data, based on the single purpose for which the dam was constructed, is considered pertinent:

(1) Hydrology

Overflow Spillway Release:

Elevation (M.S.L.)	Height Above Spillway Crest (feet)	Flow (c.f.s.)
14.4	0	0
14.9	0.5	148
15.4	1.0	455
15.9	1.5	870

Elevation (M.S.L.)	Height Above Spillway Crest (feet)	Flow (c.f.s.)
16.4	2.0	1370
16.9	2.5	1910
17.4	3.0	2510
17.9	3.5	3150
18.4	4.0	3780
19.4	5.0	5100*

* (From extrapolation of A-E's spillway rating curve)

Drainage Area Above Damsite: 32 square miles

(2) Reservoir Storage

	Elevation (M.S.L.)	Surface Area (Acres)	Storage Allocation (Acre-Feet)
Normal Pool	14.4	170.8	590
Top of Dam	19.4	331.5**	1835**

**Developed Data by Investigating Team

(3) Dam

Type: Earth Embankment and Concrete Overflow Structure

Height at Maximum Section: 18 feet

Top Width: 15-50 feet (variable, right side)
15 feet (left side)

Top Length: 820 feet

Freeboard above spillway crest: 5 feet

(4) Overflow Structure

Type: Uncontrolled, ogee-shaped gravity wall

Crest Elevation: +14.4 feet m.s.l.

Maximum Discharge: 5100 c.f.s.

(5) Drawdown Facilities

Type of Conduit: 24-inch diameter cast iron pipe

Capacity at Spillway Crest: 55 c.f.s.

Capacity at Top of Dam: 68 c.f.s.

Invert Elevation at Intake: +4.4 feet m.s.l.

Invert Elevation at Outlet: +4.4 feet m.s.l.

(6) Gates

Type: Sluice, manually operated

Number and Size: One, 2'7" x 2'4"

5. SUMMARY OF ENGINEERING DATA AVAILABLE.

a. Design - The engineering data available is contained on plan numbers 44023-2 thru 44023-5 and 44023-9, presented hereafter. The data consists of hydrologic data and test boring logs. No detailed computations or methods are available for use in determining original design assumptions. Evaluation of the structural stability of the dam, as constructed, was made and the results are contained hereafter and in Appendix E.

b. Construction - Available construction data consists of shop drawings for the overflow structure reinforcement and forming details for the overflow structure concrete placement. No other construction data was made available.

c. Operation - No operating data was made available to the inspection party. The only operation which is normally performed at Silver Lake consists of reservoir drawdown previously mentioned in paragraph 4g heretofore. No records are maintained concerning pool elevations during the drawdown and ensuing refilling or of dates on which the operation was commenced or completed.

d. Evaluation - Based on data presented to the inspection team, evaluation of the adequacy of the design and construction procedures used at the Silver Lake Project is difficult.

6. RESULT OF VISUAL INSPECTION. The detailed visual inspection checklist compiled during the 13 December 1977 inspection of Silver Lake is contained in Appendix A. Comments made by the team members were recorded and are summarized below:

a. Embankment

(1) Surface cracks: None noted

(2) Unusual moving or cracking at or beyond toe: None noted

(3) Sloughing or erosion of embankment and abutment slopes: Sloughing was noted along the upstream embankment slope immediately left of the overflow structure. The sloughing appears to be the result of wave action; maintenance personnel attempted to alleviate the erosive action by placing 4-inch nominal ballast stone in the area. Stone appears unsatisfactory; see comment 6b (4) concerning the stone.

(4) Vertical and horizontal alignment of the crest: The dam crest left of the overflow structure appears satisfactory with a uniform 15-foot width and a

reasonalbe horizontal plane. The right abutment crest varies in width from 15 to 50 feet and contains a low area adjacent to the right abutment. The low area, adjacent to a swimming beach and parking area, appears recently regraded to an elevation approximately 6 inches lower than the remainder of the embankment. This "saddle" would be the initial area of overtopping in the event the overflow spillway capacity was exceeded.

(5) Riprap failures: No riprap protection was incorporated into the Silver Lake Project. It now appears that corrective measures to alleviate wave erosion would involve riprap placement, however, stone placed to date appears undersized, poorly graded and generally is considered unsatisfactory.

(6) Junction of embankment and abutment, spillway and dam: Erosion was noted adjacent to the overflow structures-embankment junction. It appears that the unvegetated embankment material behind the walls has been eroded due to normal rainfall runoff. No visual evidence of erosion or sloughing was noted at the embankment/abutment junctions.

(7) Seepage: Seepage through the right embankment area was noted discharging into a storm water drainage swale approximately 400 feet downstream from the dam centerline. Invert elevation of the drainage swale is approximately 11 feet below normal pool elevation. No material transport was evident at the seepage locations and the seepage quantity does not appear of major significance although flow readings were not obtained or available.

(8) Staff gage and recorder: A reservoir elevation staff gage exists on the drawdown intake structure, however, the gage appears deteriorated to the extent of replacement. No readings can be obtained from this gage. A U.S.G.S. water stage recorder is maintained on the St. Jones River approximately 1,950 feet downstream from the project site. Discharge records are available from 1958 to date; a period of approximately 20 years.

(9) Drains: No drainage system was incorporated as part of the structure.

(10) Maintenance: Several large trees exist on the dam embankment immediately adjacent to the overflow structure abutment walls. The validity of allowing tree growth on the embankment is questionable. While the trees may enhance the aesthetic characteristics of the embankment area and aid in preventing erosion, deterioration of the root system and piping of the remaining cavity could result in embankment failure.

b. Outlet Works (24-inch cast iron pipe, sluice gate and operating platform)

(1) Intake structure: Operating platform and sluice gate reported as operable; used on an annual basis to lower reservoir for beach cleaning and dock repairing. Owner representatives indicate diver is necessary to clean debris from sluice gate for complete closure, therefore, sluice gate was not operated; inclement weather (cold) precluded diving.

(2) Outlet Structure: Minor cavitation of concrete outlet at downstream face of overflow structure noted. Cast iron pipe was not cut to meet ogee overflow slope, end section was formed from concrete.

(3) Outlet channel: The outlet channel immediately downstream of the overflow structure makes an abrupt 45-degree turn towards the left bank. The turn has created an erosion problem along the downstream right bank and corrective measures were undertaken to alleviate the erosion by placing 4-inch nominal ballast stone in the undercut area. The ballast stone appears very poorly graded, undersized and is considered unsatisfactory to prevent erosion during high discharges.

(4) Emergency gate: The sluice gate was not inspected, but is reportedly operable; see paragraph 6b(2) heretofore.

c. Ungated Spillway (Concrete ogee overflow structure)

(1) Concrete weir: The ogee weir was designed for use of flashboards to raise reservoir pool or to minimize surging over the spillway crest caused by wave action. The flashboards are currently not available.

Numerous small popouts were noted in the downstream concrete ogee surface. The popouts, some of which appear to be tie rod patches, vary in size from 1/2-3 inches in diameter. The second monolith from east abutment contains two holes, approximately 1-1 1/2 feet horizontally, 2-3 inches wide, 10-12 feet from the west monolith edge and 3 feet above ogee bottom. The overall wier structure concrete appears to be in satisfactory condition. However, pool elevation precluded complete and thorough inspection of the upstream face.

(2) Approach channel (concrete): The approach end of the left abutment overflow structure wall shows evidence of deteriorated concrete at the fluctuating freeze-thaw reservoir pool elevation. The right abutment wall approach end does not show this condition.

(3) Discharge channel (concrete): End of ogee of monoliths 3, 4, and 5 (from east) show signs of cavitation. Cavitation may be the result of misalignment between the ogee and runout slab monoliths; ogee end may be low or runout slab high. Both abutment walls contain full width, top to bottom cracks downstream of the crest. Both cracks indicate water seepage and partial calcite healing.

(4) Bridge and piers: A three-foot wide concrete walkway was constructed at top of dam elevation with support provided by vertical pedestals across the ogee weir crest. Several major longitudinal cracks were observed, 4 and 5 feet long, in the walkway above bay 5 (from left bank). Full length transverse cracks were observed at pedestal 6, and 10 feet left of pedestal 8. Generally, the underside of the walkway appeared badly spalled and deteriorated to the point of requiring replacement. The pedestals appeared cavitated at the spillway crest-pedestal flow line construction joint.

d. Reservoir

(1) Slopes: Upstream embankment slope, left bank at approach wall appears

severely eroded; four-inch stone placed during summer of 1976 as protective measure. Downstream slopes, left bank, approximately 2H-1V with erosion behind both abutment walls. See comment, paragraph 6a(6).

(2) Sedimentation: Verbal indication by owner representatives that sedimentation, particularly in area adjacent to drawdown intake structure, is not a problem. No sedimentation studies have been conducted for the project reservoir.

e. Downstream Channel

(1) Condition: A 45-degree turn, immediately downstream of the overflow structure, alters the hydraulic characteristics of the downstream channel during high discharges (See paragraph 6c(3) heretofore). Several bridges, particularly those at Lockerman Street and Division Street, provide downstream restrictions which would impede flow during extremely high reservoir discharges.

(2) Slopes: The flood plain downstream of the project is primarily well-sodded park land with very flat slopes. The St. Jones River becomes tidal immediately below the Lockerman Street bridge.

(3) Approximate number of homes and population: From local information, it appears that the only structure subjected to flooding is the Treadway Towers, an apartment complex with offices and a restaurant on the ground floor. The ground floor has been subjected to flooding in the past from an apparent combination of both tidal and fluvial events. It appears that the City of Dover has implemented an aggressive plan of flood zone management within their jurisdictional boundaries along the St. Jones River.

f. Miscellaneous - While not within the checklist items to be inspected by the team members, several items of safety were noted and are considered relevant to any field examination made by representatives of the Corps of Engineers. The specific safety deficiencies are as follows:

(1) Both overflow structure abutments are unguarded. A fall from either abutment wall would result in a 15-foot drop to the concrete ogee section or runout slab section below. Safety fencing of these areas is advised.

(2) No deterrent to boating in the overflow structure/sluice gate platform area was noted. A floating boom or off limits sign should discourage people from entering this area.

7. OPERATIONAL PROCEDURES. In general, no operational procedures have been established for maintenance of the dam or operating facilities. The maintenance is accomplished on an as-needed basis when funds are available. According to owners representatives, there is an effort underway to program funds for 1980 to repair some deteriorated concrete in the overflow structure and extend the runout slab. Evaluation of the present operational procedures in effect at the project indicates that a planned program for periodic inspection and maintenance should be formulated by the City of Dover to insure continued project function without significant public endangerment.

8. DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT. Conversations with owners representatives indicate that no warning system is presently in use at the Silver Lake Project. Maintenance and operations personnel monitor project functioning during instances of severe flooding when the flooding is forecasted or in effect, however, advance warning, particularly during off-duty hours for responsible personnel, is not available. A warning device should be interlocked with the stream gage station located downstream of the project to alert owner representatives of high discharge-critical project flows. Due to the potential for overtopping of the dam, a detailed emergency operation and warning system should be developed by the owner.

9. EVALUATION OF HYDROLOGIC AND HYDRAULIC FEATURES.

a. Design Data - The original design for spillway size determination, as shown on contract drawing 44023-1 dated 7 July 1944, indicates that the designed spillway section would discharge 118 c.f.s. per square mile of drainage area at a four foot head above spillway crest. A tabulation showing discharge from "comparable" areas in New Jersey also contained on the drawing and extrapolated from U.S.G.S. publication "Surface Water Supply of the United States, 1941" indicates that the maximum event for the publication period occurred on the Maurice River at Norma, New Jersey, 2 September 1940, with a maximum discharge of 65.2 c.f.s. per square mile of drainage area. It appears that the original sizing of the spillway for Silver Lake reconstruction was predicated on approximately doubling the maximum discharge experienced in New Jersey during the 1939-1940 publication period. This method is not considered acceptable for use in evaluating the safety of the dam for several reasons; the maximum discharge experienced in New Jersey is predicated on a relatively short period of record and the "comparability" of the New Jersey/Delaware hydrologic areas is questionable. The spillway rating curve for the constructed overflow section shown on the same contract drawing, is considered valid and was used in evaluating the overtopping potential of the dam.

Daily and peak flow data is available for the St. Jones River-U.S. Geological Survey gaging station located downstream of the project site. This data, presented in the annual surface Water Records Publication, indicates that a maximum event for the twenty year period of record occurred on 13 September 1960 when a discharge of 1,900 c.f.s. was experienced at the gage station site. For this discharge, a pool elevation of 16.9 or 2.5 feet above spillway crest elevation would be necessary at the dam site.

No hydraulic or hydrologic data is available for the following:

(1) Spillway design flood

(a) Storm precipitation, pattern or frequency

(b) Spillway design flood hydrograph

(2) Reservoir area-capacity versus pool elevation curves or tables

(3) Outlet works rating curves

(4) Tailwater rating curves below the dam

(5) Minimum non-damaging downstream capacity

b. Experience Data - No operating personnel are assigned to the project to monitor reservoir behavior, therefore, no watershed rainfall or reservoir records are available for hydraulic evaluation or overtopping potential. It is believed that an estimate of the design flood, based on conservative generalized events which have occurred on a comparable hydrologic region is more beneficial for hydraulic evaluation of the Silver Lake Dam than the very limited experience data presently available. This analysis, complete with assumptions, methodology, and calculations is contained in Appendix D.

10. EVALUATION OF STRUCTURAL STABILITY.

a. Design and Construction Data - The structural stability of the overflow structure was evaluated for seepage around abutment walls and for overturning and sliding of the concrete gravity structure. The geometry of the gravity structure and material characteristics were obtained from the contract drawings available for the project.

(1) Seepage: Creep ratios were determined for several seepage paths along the side and bottom of the overflow structure abutment walls. This area was considered critical since the embankment section is minimal adjacent to the overflow structure and wider at all other sections. The creep ratios computed were in excess of that considered minimal for silt and silt-sand mixtures characteristic of the area and shown on the available boring logs. Sheet piling, which extends approximately four feet into the embankment behind the abutment walls and twelve feet below the abutment wall, was considered in the analysis. The creep ratios were determined in accordance with the Corps of Engineers Manual for Flood Wall Design.

(2) Gravity Wall Stability: The gravity wall was evaluated for sliding and overturning in accordance with Corps of Engineers Manual for Gravity Wall Design and Corps of Engineers Technical Letter for Gravity Dam Design Stability. The factor of safety for sliding resistance was 1.5, which is somewhat lower than recommended, however, the evaluation was purposely made conservative by neglecting the sheet piling and upstream and downstream toes. The overturning analysis indicated that the resultant would act approximately one-third of the base distance from the upstream end. The analysis is contained in Appendix E.

b. Operational Records - Operational records are of little use in evaluation of the structural stability of this project since the available information is minimal. Downstream streamflow records indicate the project has experienced reservoir elevations approximately 2½ feet above spillway crest during the 20 year record period. No adverse affects on the structural stability of the project features were reported as a result of this event, nor is there any visual evidence of past or present distress which may have been caused by the preceding events.

c. Post-Construction Changes - Several significant post-construction changes have been made at Silver Lake which have increased the structural stability of the project. The most notable changes involve flattening of the downstream slopes to provide usable recreation and parking areas. The downstream right embnakment slope has been filled to provide picnic, parking, and beach facilities. The downstream left embankment slope has been extended to

provide a boat launching parking lot and access roads. The embankment areas that have remained as originally designed (i.e. with 1 Vertical:2½ Horizontal slopes) are those immediately adjacent to the overflow structure abutment walls. Since these sections are not extensive (approximately 10 feet behind the right abutment wall and 25 feet behind the left abutment wall) no embankment stability analysis is considered necessary. The average downstream slope right of the overflow structure is approximately 1V:50H and that left of the overflow structure is approximately 1V:5H.

d. Seismic Stability - An assessment of the potential vulnerability of the dam to seismic events indicates that the project is located in Seismic Zone 1. Since projects located in this zone present no hazard from earthquakes when static stability conditions are satisfactory, the Silver Lake project is considered seismically stable.

11. DAM ASSESSMENT.

a. General - Based on the available data and visual inspection of the project, Silver Lake is considered an adequate structure, however, the overflow spillway is inadequate to accomodate the 100 year event. Since the embankment will be overtopped within the life of the project, several remedial courses of action were considered and the most feasable alternative is to allow the overtopping to occur. Team members feel that with proper preparation for the overtopping, by institution of an adequate warning and emergency operations system, the potential for loss of life or economic loss is minimal. In addition, the cohesive silt and sandy silt material used for embankment construction offers resistance to erosion and, therefore, breaching of the dam embankment would occur slowly in the event of overtopping. A further factor of safety has been incorporated into the project by construction of a saddle area near the right abutment. This saddle area would provide floodwaters with an overtopping path on a slope of 1V:50H for a distance of 400 feet, thereby allowing a slow breaching of the embankment and a slow release of the reservoir impoundment.

b. Adequacy of Information - While additional information would be useful in conducting a more detailed analysis of the project, particularly with respect to the hydraulic and hydrologic evaluation, this information is not considered necessary for project assessment. The report has assessed both the embankment and overflow structure for stability with satisfactory results and accepts dam overtopping as a project occurrence.

c. Urgency - No additional studies, investigations, or analysis for the project are recommended. Team members recommend timely formulation of a warning and emergency operations program by the owner to assure minimizing downstream hazard potential.

12. REMEDIAL MEASURES.

a. Alternates - The evaluation and assessment of Silver Lake indicates one problem area; overtopping of the embankment. Four alternate courses of

action to the overtopping problem were investigated and are discussed below.

(1) Embankment Raising: Raising of the embankment and overflow structure abutment walls to elevation 26.4 SLD, 7 feet above the present top of dam, would allow safe passage of the 100 year event. This action, while economically feasable from a construction cost standpoint, would endanger considerable private property located along the reservoir shoreline. A majority of the reservoir perimeter is developed primarily with apartment complexes and single residences, and inundation of this area would occur at elevation 26.4. Due to the increased hazard potential associated with inundation of the shoreline areas, this alternate is not considered acceptable.

(2) Overflow Structure Widening: Widening the overflow structure from 150 feet to approximately 430 feet would safely allow passage of the 100 year event without embankment overtopping. This course of action, while not affecting upstream shoreline properties, would be uneconomical from a construction cost standpoint. In addition, this alternative would allow greater flow through the reservoir during small magnitude floods (less than the spillway capacity of 5,100 c.f.s.) than the present overflow structure, thereby subjecting downstream areas to greater flooding. Although the project is not operated as a flood control structure, approximately 1,250 acre-feet of storage is available between spillway crest and top of dam elevation in the reservoir area.

(3) Drawdown Reservoir-Breach Embankment: This course of action eliminates the project in its present condition. Major objectives to this alternate include loss of the reservoir flood storage capability.

(4) No Change: The alternate allows overtopping of the embankment and possible breaching of the top of dam. Although damages and economic losses would be suffered downstream of the project site, the flood plain management program presently in affect along the St. Jones River would minimize damage. Implementation of a warning system and formulation of an emergency operations program for notification of downstream personnel, would minimize the loss of life hazard in the event of a major flood. This alternative appears most advantageous of those investigated.

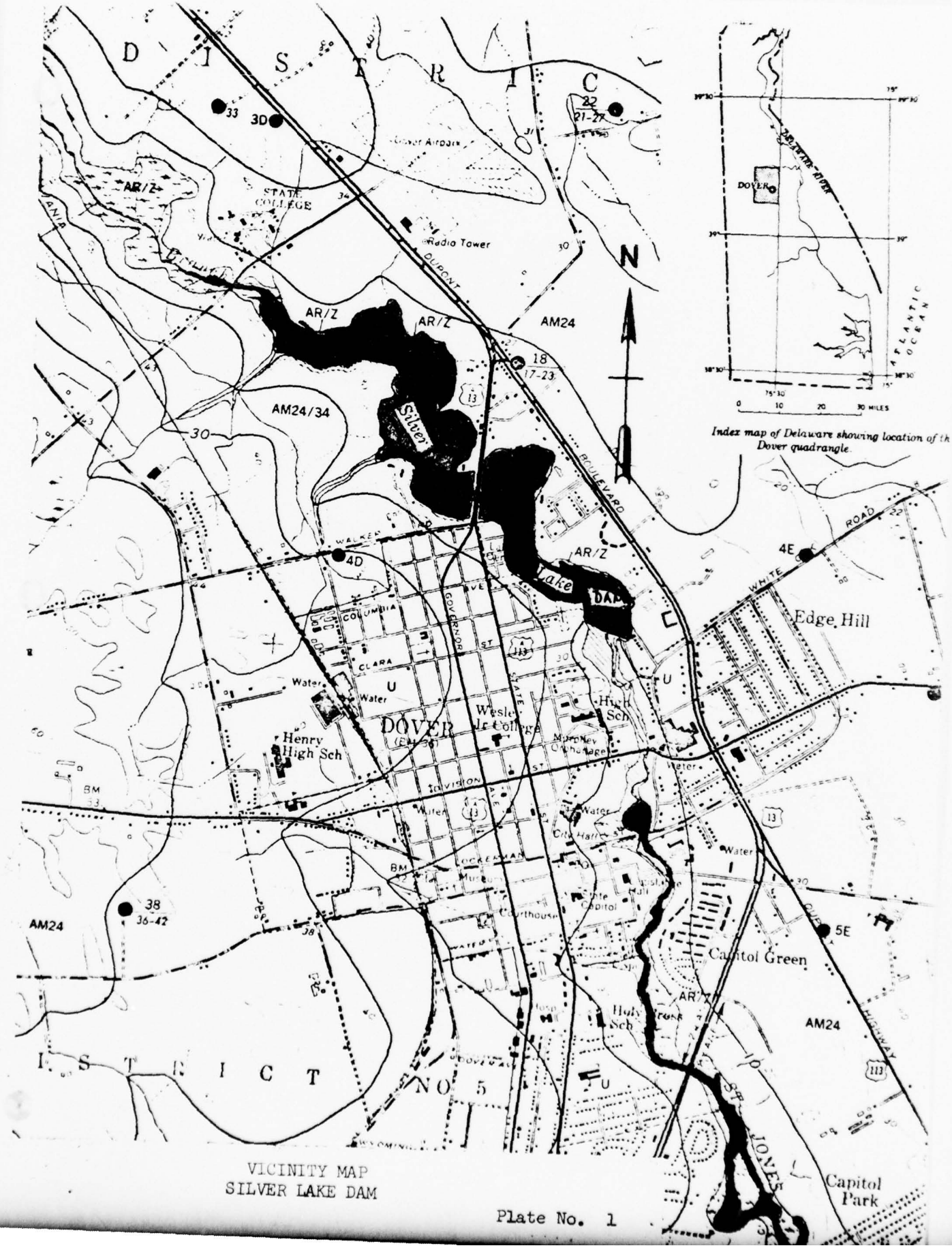
b. Operations and Maintenance Procedures - The inspection team recommends formulation of a periodic inspection, maintenance, and emergency operations program for the project.

(1) Maintenance: The maintenance program should include designing, planning and funding for major repair work, as warranted. In addition, everyday maintenance responsibilities, such as repairing minor concrete spalls, erosion, riprap, turfing, etc., should be scheduled to assure completion.

(2) Periodic Inspection: The periodic inspection program should follow the checklist contained in Appendix A of this report. The inspection should be performed at least annually and during major flooding conditions. Conditions which require remedial effort should be included in the updated maintenance program.

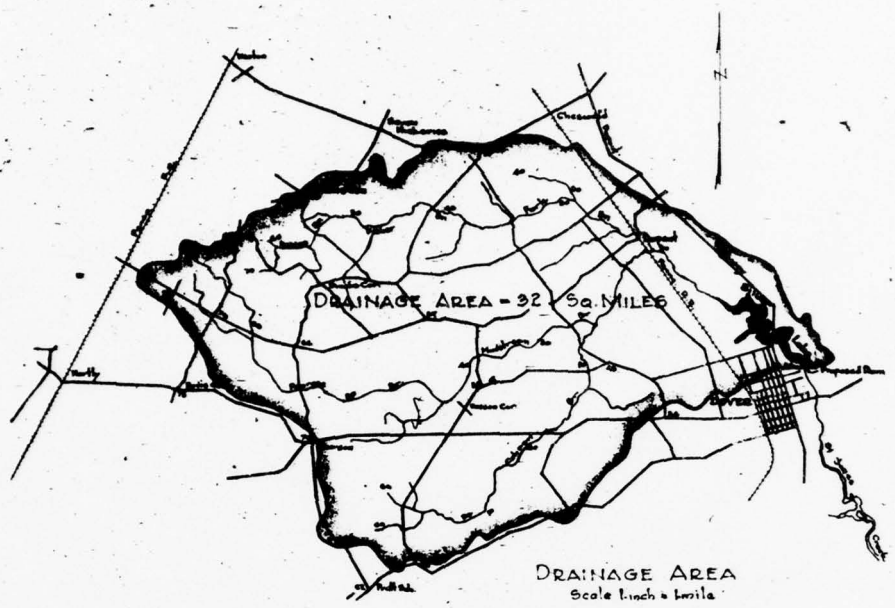
(3) Emergency Operations: The emergency operations program should be

formulated for the purpose of preventing loss of life and minimizing economic losses in the event of an embankment overtopping. The program should designate personnel, and assign responsibilities, for notifying downstream residents, closing roadways, providing emergency flood and shelter, and directing rescue and cleanup operations.



VICINITY MAP
SILVER LAKE DAM

Plate No. 1



DRAINAGE AREA
Scale 1 inch = 1 mile

TABULATION SHOWING DISCHAR
FROM COMPARABLE AREAS IN NE

Page	Location	Stream	Date of Maximum Flow	Drainage Area Sq. Miles	
335	Norma, N.J.	Maurice River	9-2-40	119.0	
334	Folsom, N.J.	Great Egg River	9-3-40	86.8	
336	Millville, N.J.	Manantico Crk.	8-20-39	22.9	
984	Pemberton, N.J.	Rancocas Crk. North Branch	8-21-39	111.0	
939	Harrisville, N.J.	Wading River East Branch	8-20-39	64.0	
992	Dolsto, N.J.	Dobie River	9-3-40	70.5	

Copied from U.S. Dept of Interior
Surface Water Supply of U.S. 1941
Geological Survey, Water Supply Paper 921

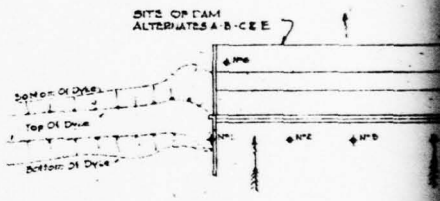
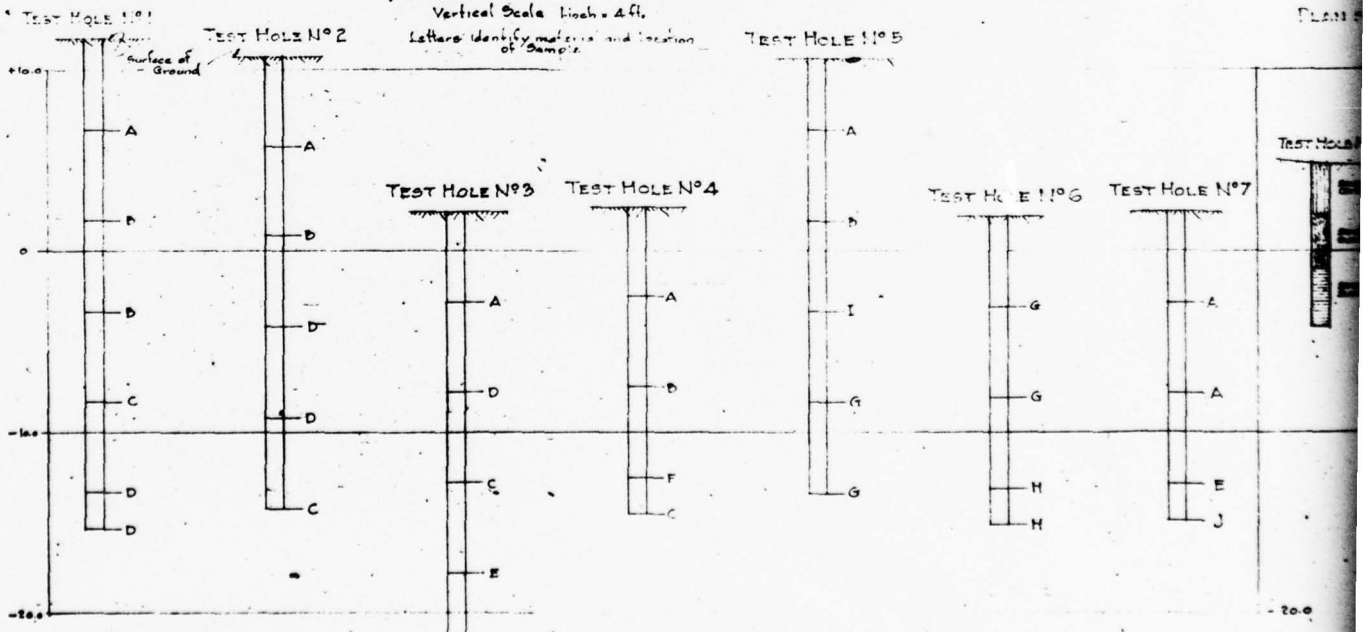
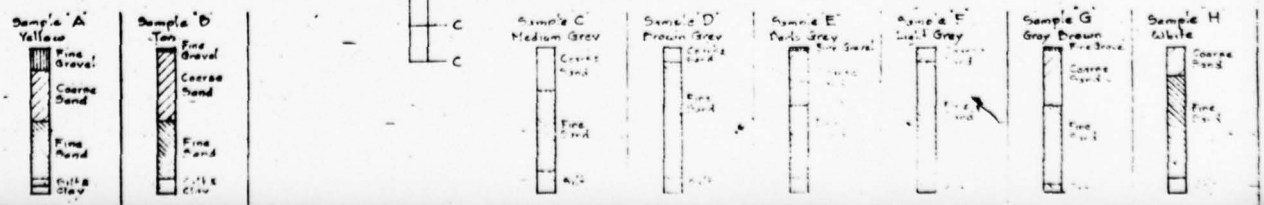


DIAGRAM OF TEST BORINGS
Vertical Scale 1 inch = 4 ft.
Letters identify materials and location of Samples





INAGE AREA
scale 1 inch = 1 mile

TABULATION SHOWING DISCHARGE
FROM COMPARABLE AREAS IN NEW JERSEY

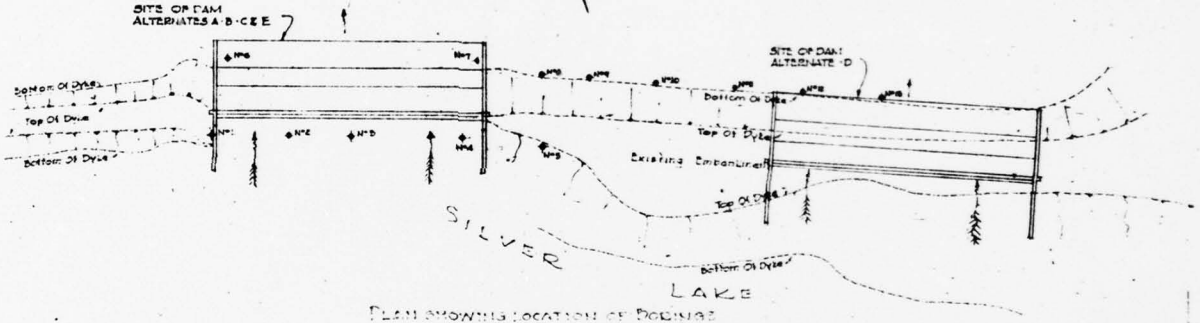
Page	Location	Stream	Date of Maximum Flow	Drainage Area Sq. Miles	Maximum Discharge c.f.s.	Discharge per Sq. Mile c.f.s.
335	Norma, N.J.	Maurice River	9-2-40	119.0	7,960	66.2
334	Folsom, N.J.	Great Egg River	9-3-40	80.5	1,440	28.7
336	Millville, N.J.	Manantico Crk.	8-20-39	22.3	1,080	47.0
384	Pemberton, N.J.	Rancocas Crk. North Branch	8-21-39	111.0	1,730	15.6
333	Harrisville, N.J.	Wading River East Branch	8-20-39	64.0	1,390	21.7
332	Batsto, N.J.	Batsto River	9-3-40	70.5	924	13.2

Copied From U.S. Dept of Interior
Surface Water Supply of U.S. 1941
Geological Survey, Water Supply Paper 921

ESTIMATED DISCHARGE OF SPILLWAY SECTION
PROPOSED SILVER LAKE DAM

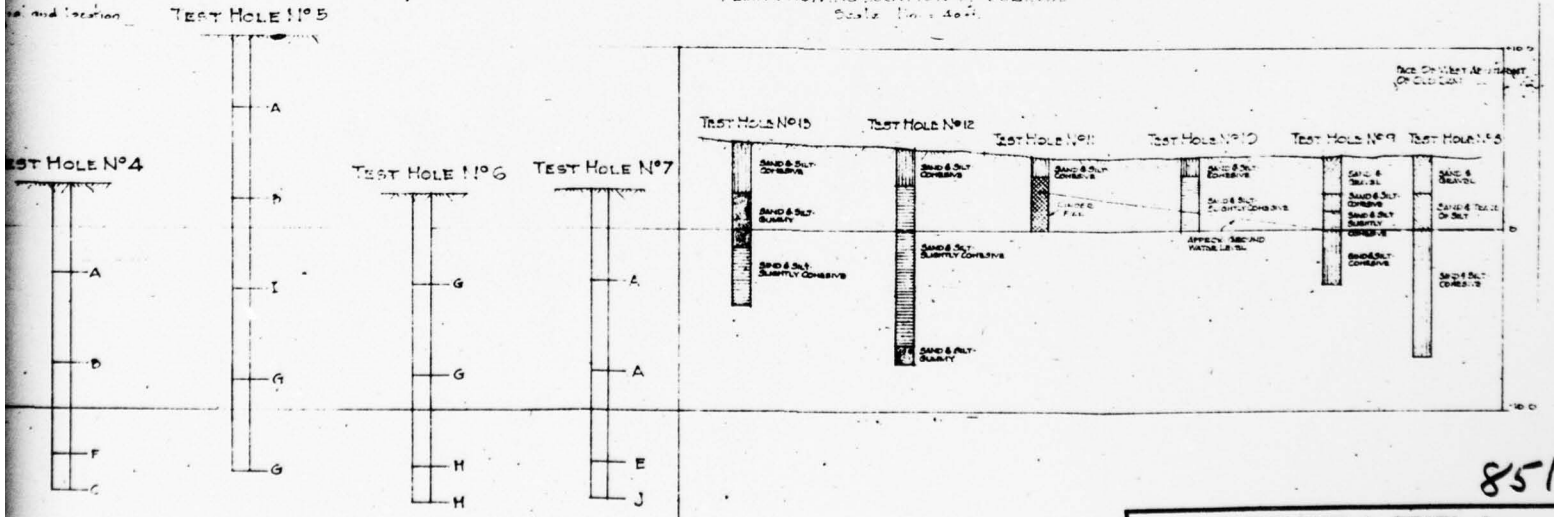
Water Level	H	Discharge c.f.s.	Discharge per Square Mile c.f.s.
12.5	0.5	148	4.6
13.0	1.0	455	14.2
13.5	1.5	870	27.2
14.0	2.0	1370	42.8
14.5	2.5	1910	59.6
15.0	3.0	2510	78.2
15.5	3.5	3150	98.5
16.0	4.0	3780	118.0

Top of dam Elev. 12.0

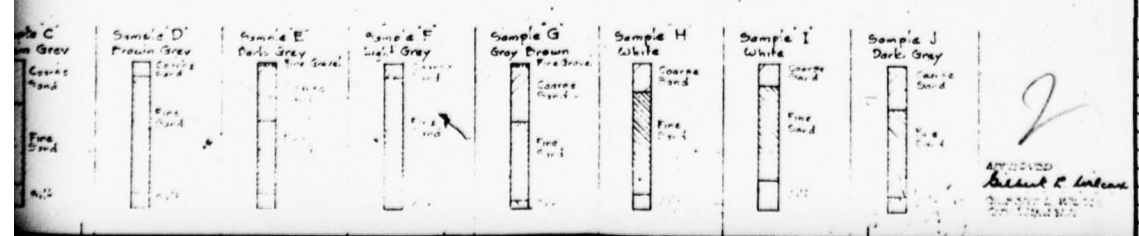


PLAN SHOWING LOCATION OF BORINGS
Scale 1in. = 40 ft.

BORINGS
h. = 4 ft.
and location



851



2

Approved
Albright & Friel
Consulting Engineers

ALBRIGHT & FRIEL, Inc.
CONSULTING — ENGINEERS
PHILADELPHIA, PA.

SCALE As Noted

REVISIONS

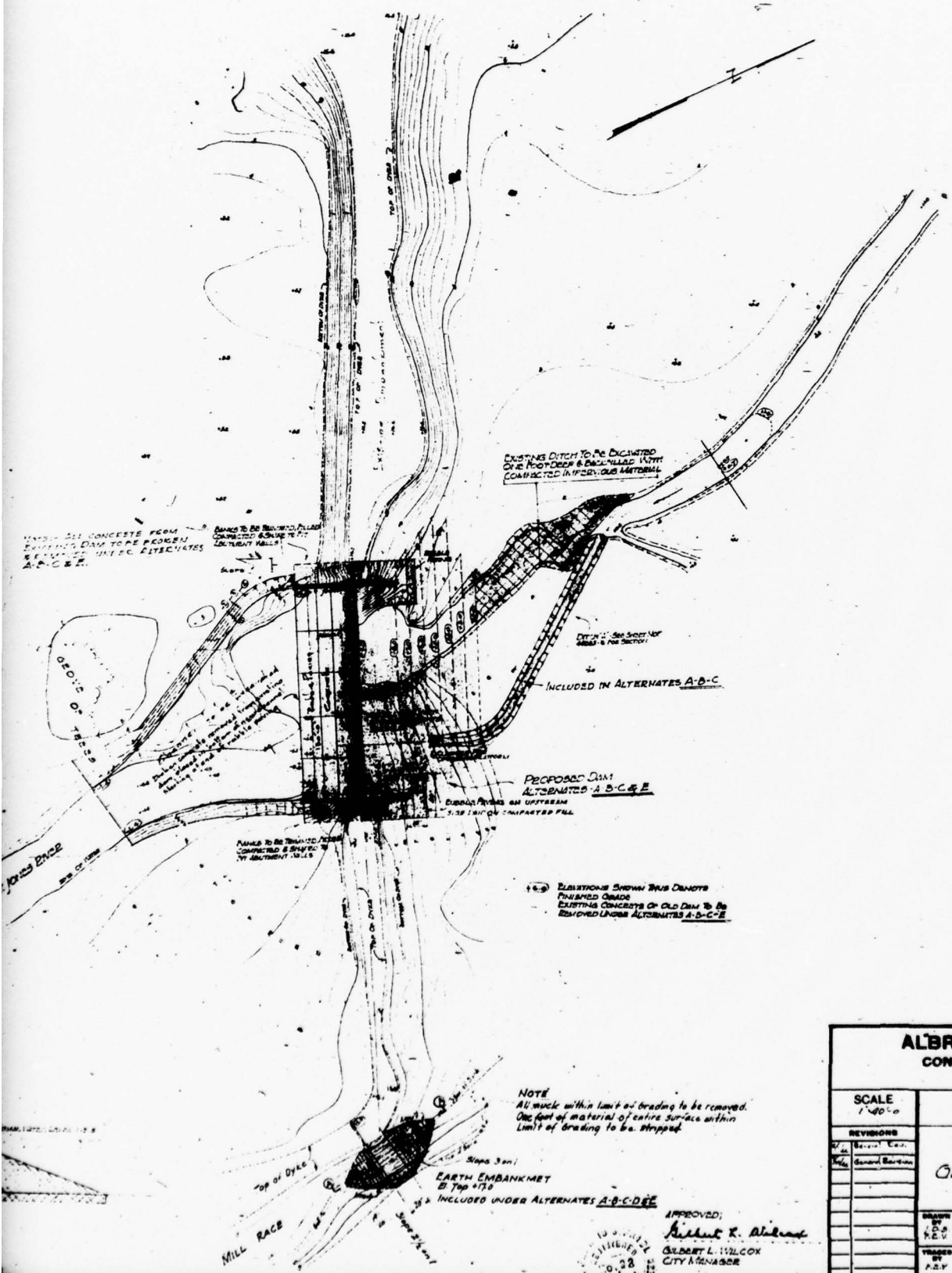
DOVER - DELAWARE

SILVER LAKE DAM
DRAINAGE AREA & BORINGS
ALTERNATES A, B, C, D & E

DRAWN BY TS
TRACED BY TS
CHECKED BY LB
APPROVED Francis D. Friel
REGISTERED PROFESSIONAL ENGINEER
DATE May 1, 1944
PLAN NUMBER 4403A-1


EXISTING DITCH TO BE EXCAVATED ONE FOOT DEEP & BACKFILLED WITH COMPACTED IMPERVIOUS MATERIAL
INCLUDED IN ALTERNATES A-B-C
PROPOSED DAM ALTERNATES A-B-C & E
ELEVATIONS SHOWN THUS DENOTE FINISHED GRADE
NOTE
EARTH EMBANKMET
Top +170
INCLUDED UNDER ALTERNATES A-B-C-D & E
MILL RACE
ST. JOHNS RIVER
20'
Previous Material Compacted in 8" Layers
Impervious Material Compacted in 6" Layers
Stripping
Toe of Mill Race
SECTION 'A-A' THROUGH EARTH EMBANKMENT AT MILL RACE
Scale 1" = 10'

2



852

NOTE
All muck within limit of grading to be removed.
One foot of material of entire surface within limit of grading to be stripped.

APPROVED;
Gilbert R. Wilcox
GILBERT L. WILCOX
CITY MANAGER

ALBRIGHT & FRIEL, Inc.
CONSULTING — ENGINEERS
PHILADELPHIA, PA.

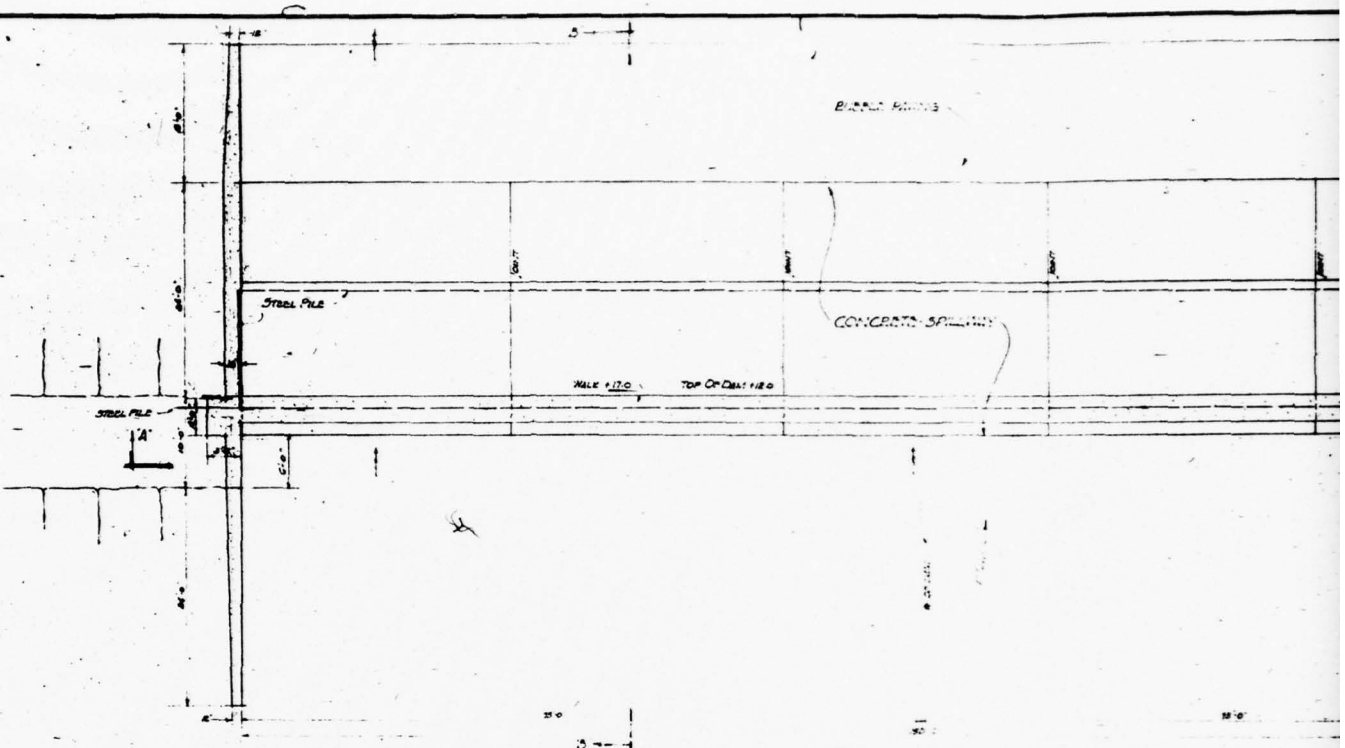
SCALE 1"=40'-0"

DOVER - DELAWARE

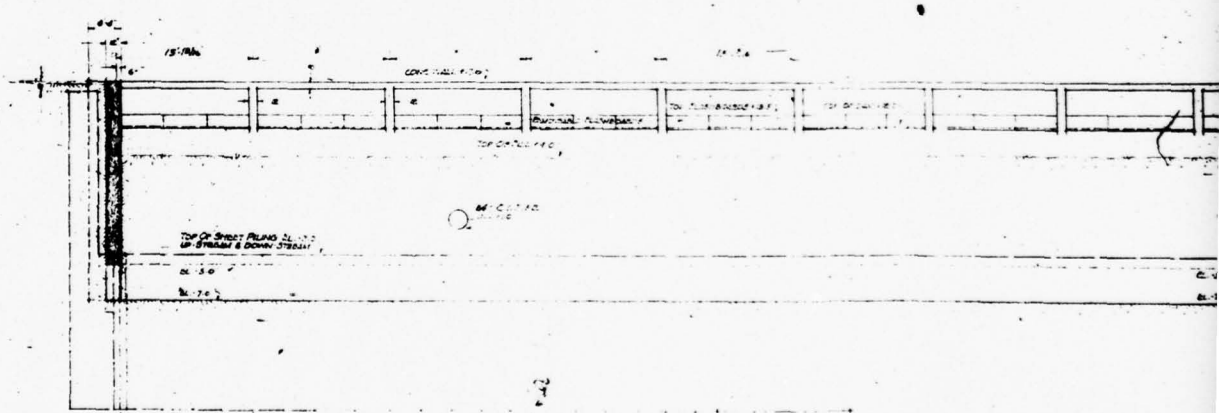
REVISIONS

SILVER LAKE DAM
GENERAL PLAN OF DAM SITE
ALTERNATES A-B-C & E

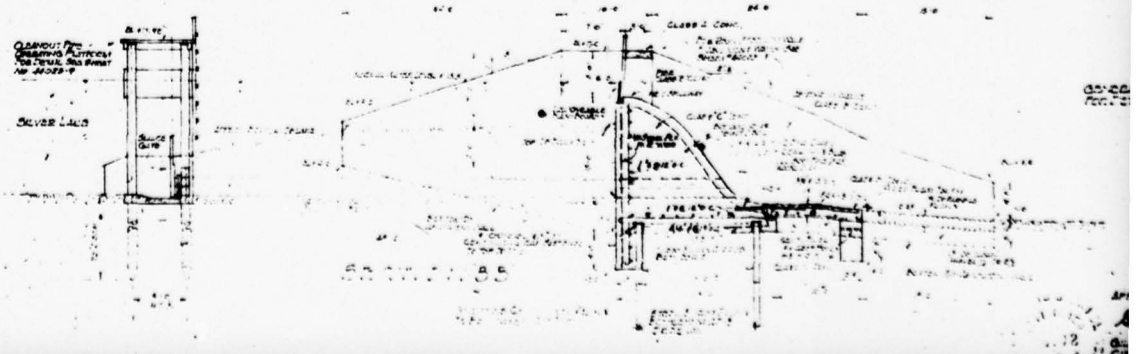
DRAWN BY J.D.S. R.E.V.
TRACED BY R.E.V.
CHECKED BY J.A.S.
APPROVED Francis D. Friel
REGISTERED PROFESSIONAL ENGINEER
DATE JULY 7 1948
PLAN NUMBER 44023-E

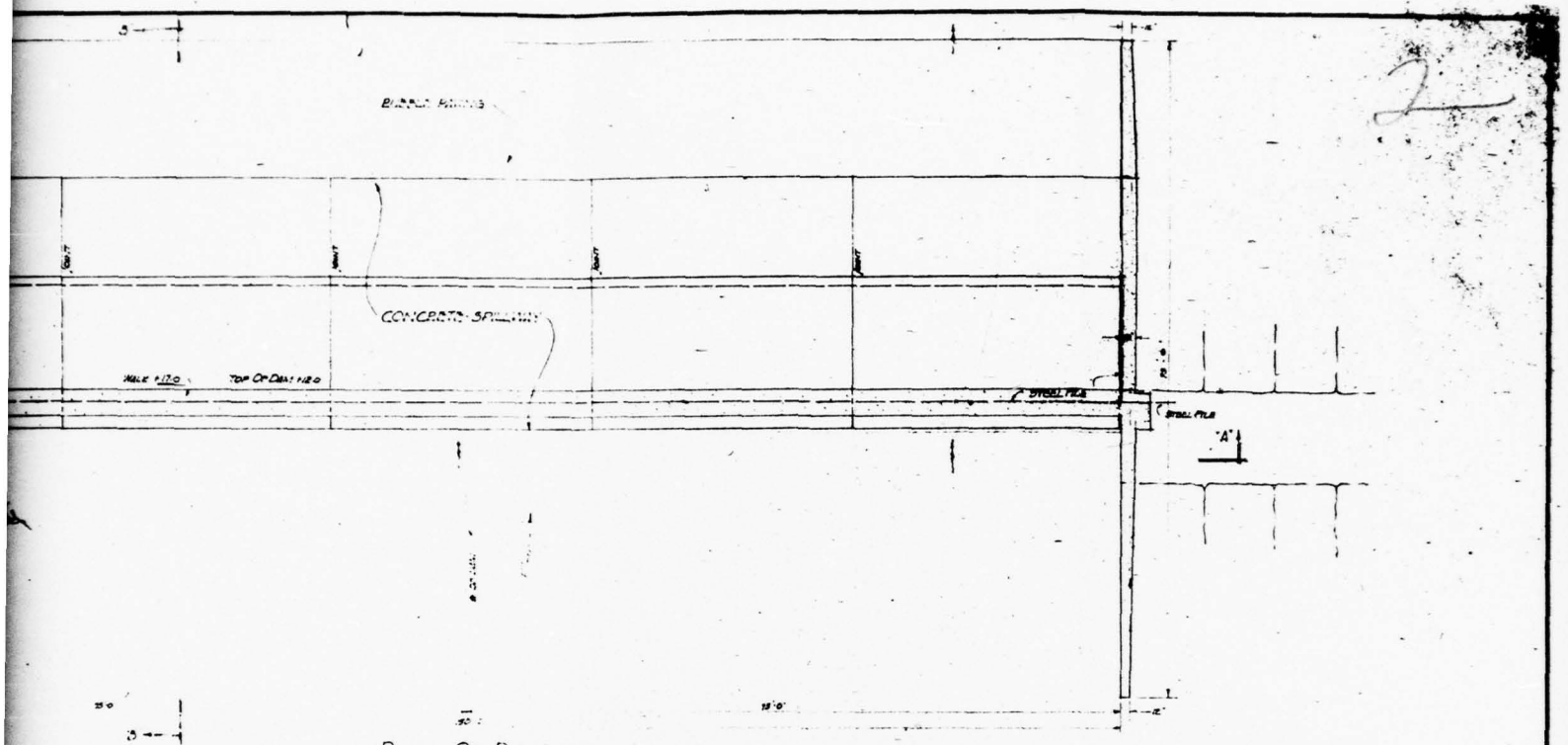


PLAN OF DAM

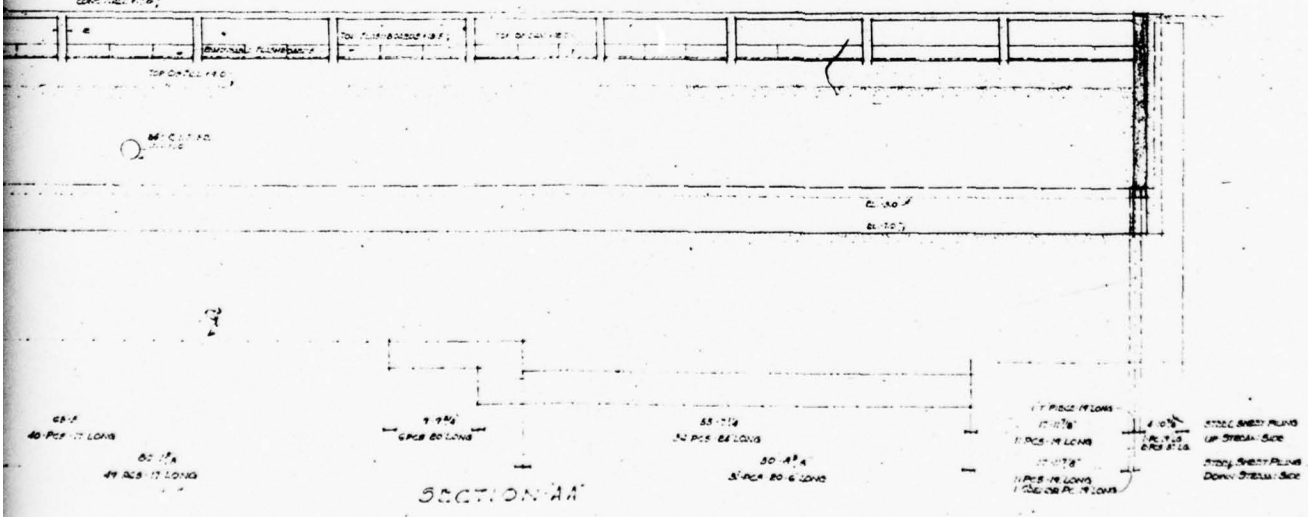


SECTION AA

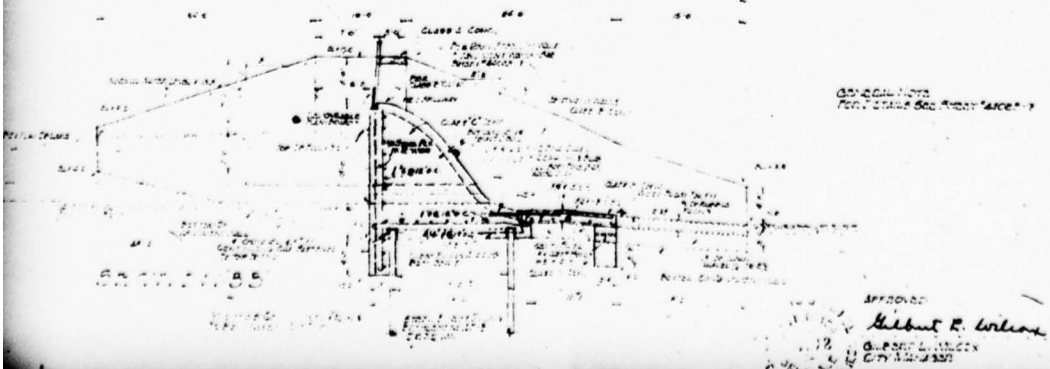




PLAN OF DAM



SECTION A-A



853

ALBRIGHT & FRIEL, Inc.
CONSULTING – ENGINEERS
PHILADELPHIA, PA.

SCALE 1/8" = 1'-0"

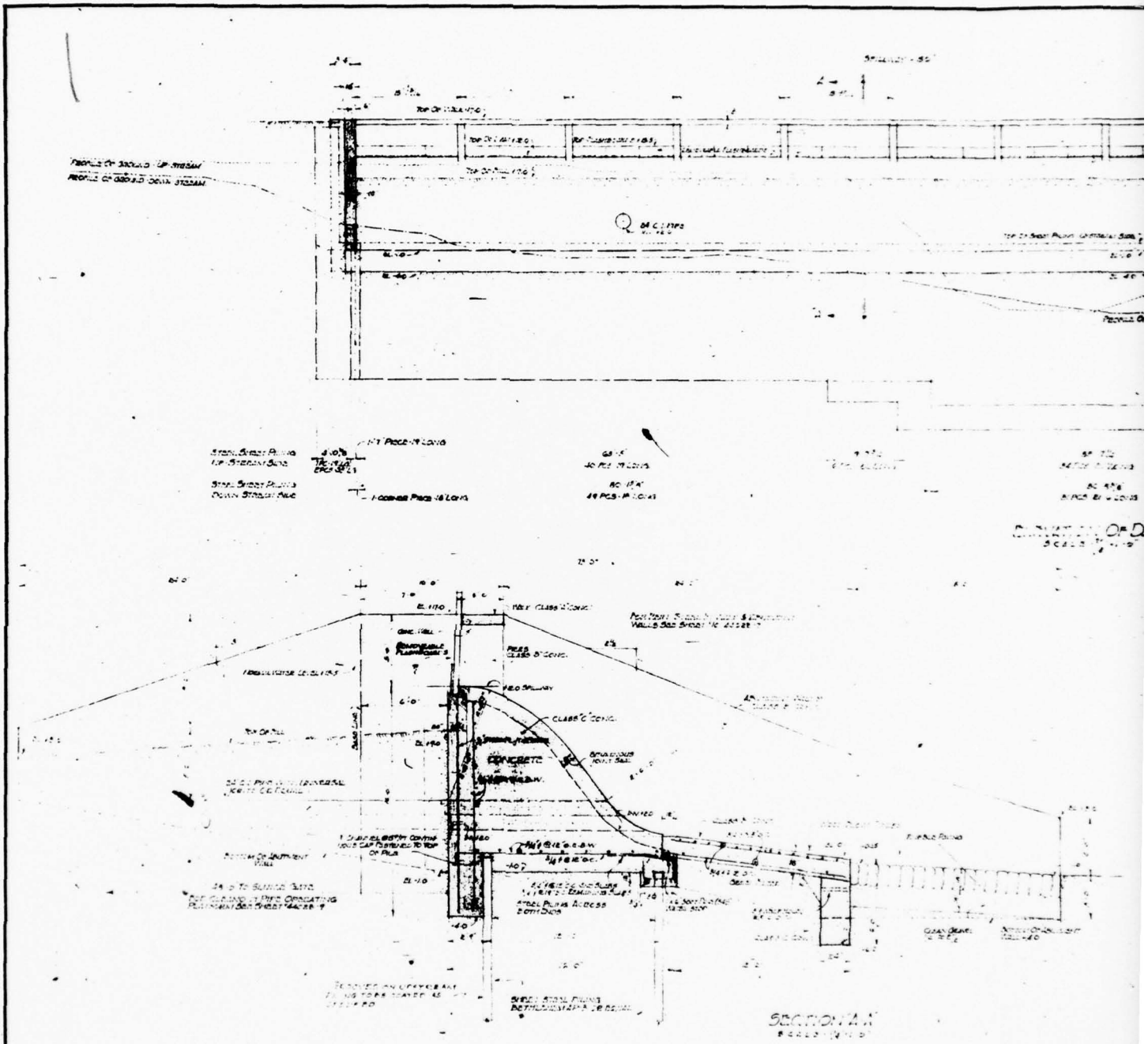
REVISIONS

DOVER DELAWARE

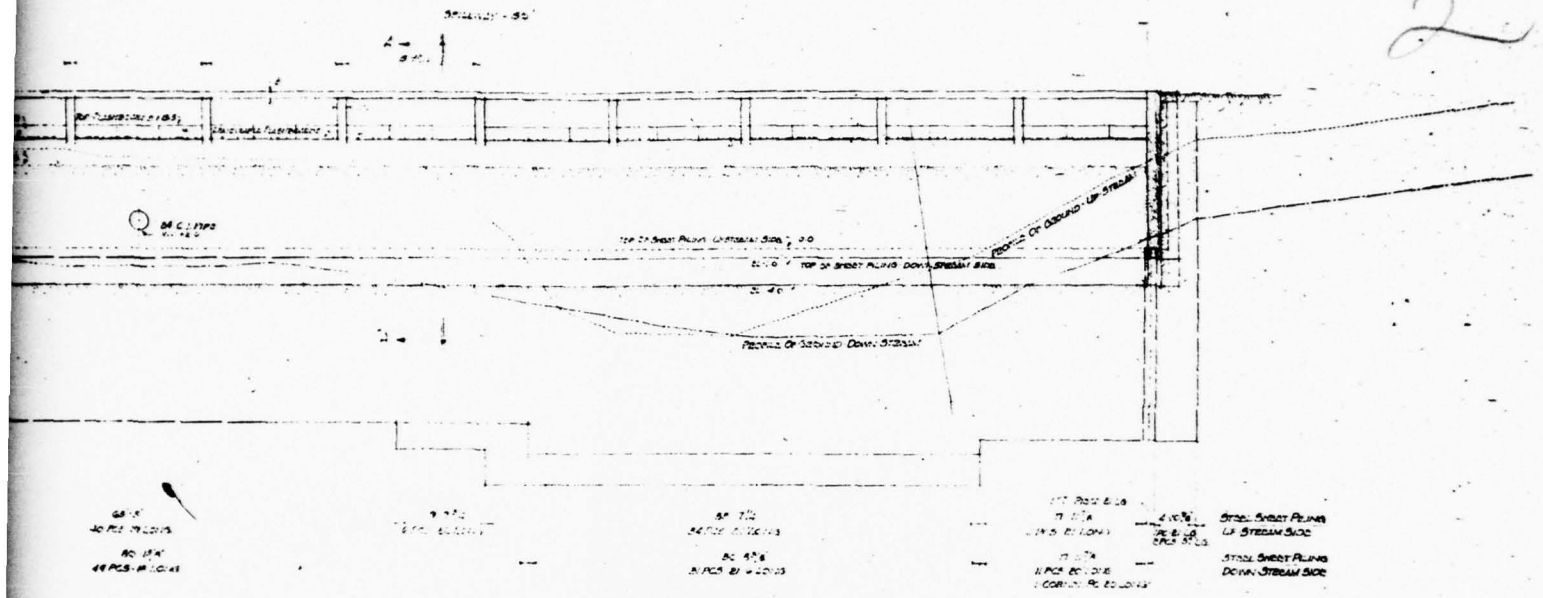
SILVER LAKE DAM
PLAN & SECTIONS
ALTERNATE 'A'

DRAWN BY: A.S.N.
CHECKED BY:
APPROVED: Marcia A. Nist
REGISTERED PROFESSIONAL ENGINEER
DATE: JULY 7-1933
PLAN NUMBER: 44023-3

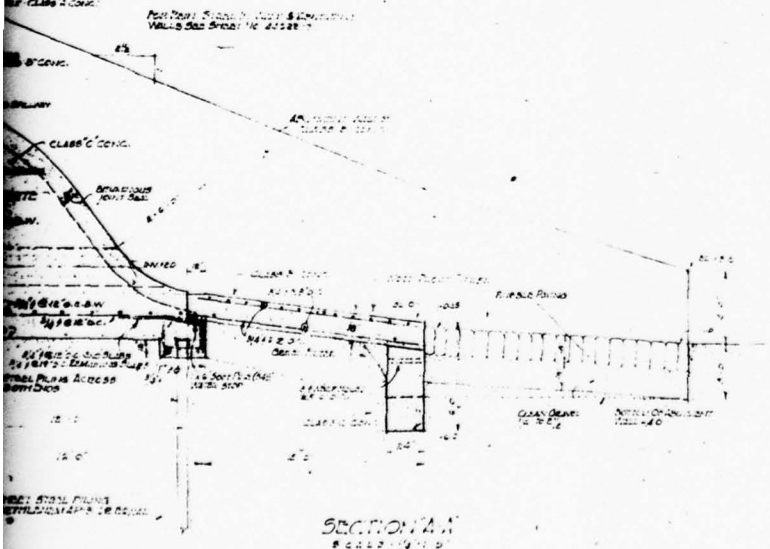
APPROVED: Gilbert R. Wilcox
CITY SOLICITOR


CONCRETE
SECTION A-A

2



ELEVATION OF DAM



SECTION A-A

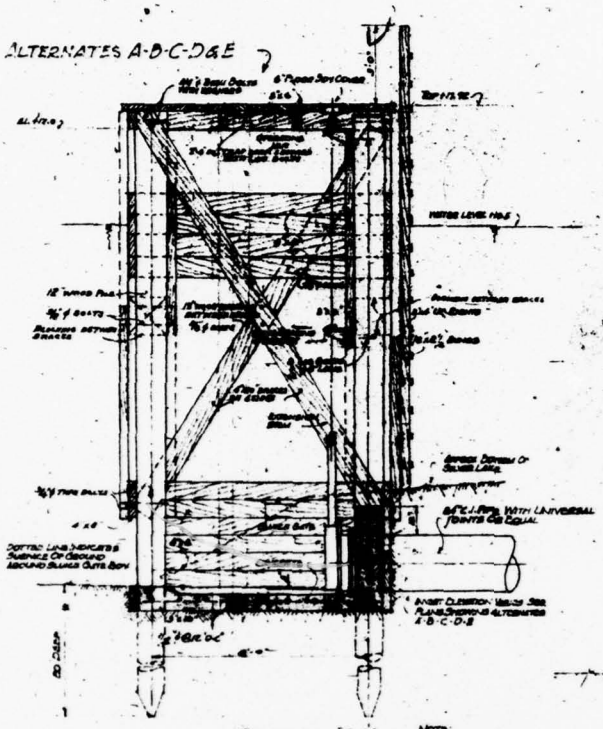
855

GENERAL NOTE
FOR DETAILS SEE SHEET NUMBER 1

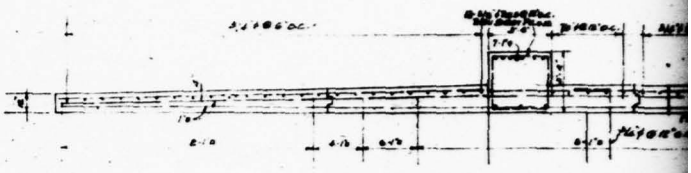
Gilbert R. Wilcox

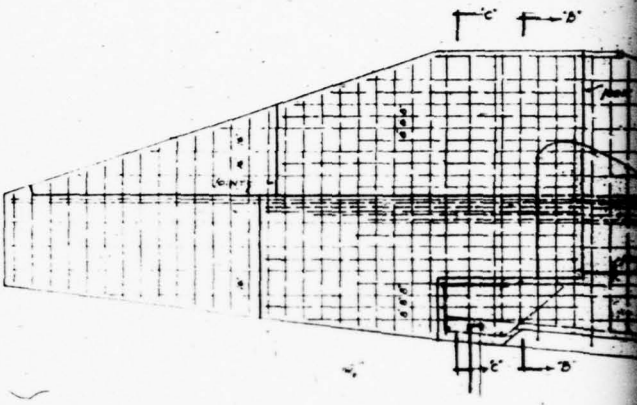
ALBRIGHT & FRIEL, Inc. CONSULTING – ENGINEERS PHILADELPHIA, PA.	
SCALE	DOWN-DRAWINGS
REVISIONS	SILVER LAKE DAM ELEVATION & SECTION ALTERNATE "C"
DRAWN BY / TRACED BY	APPROVED Maurice A. Friel REGISTERED PROFESSIONAL ENGINEER
	DATE JULY 7 1955
	PLAN NUMBER 4023-5

ALTERNATES A-B-C-D&E



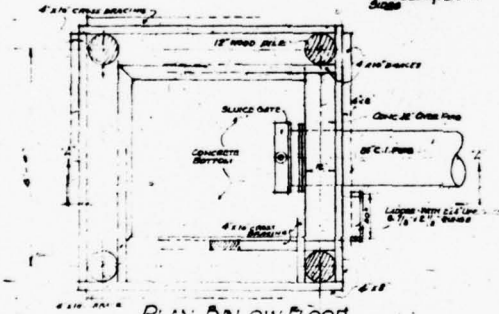
SECTION A-A





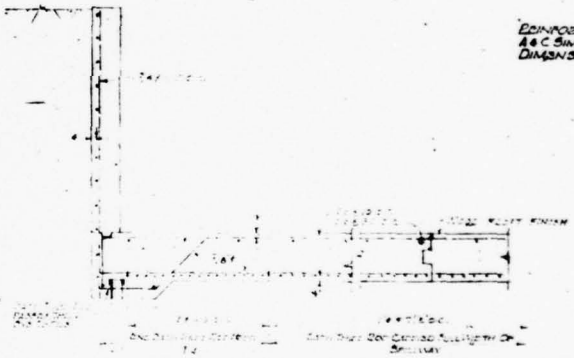
DETAIL OF ABUTMENT WALL FOR ALTERNATE "C"

REINFORCING OF ABUTMENT WALLS A & C SIMILAR EXCEPT LENGTHS VARY DIMENSIONS.

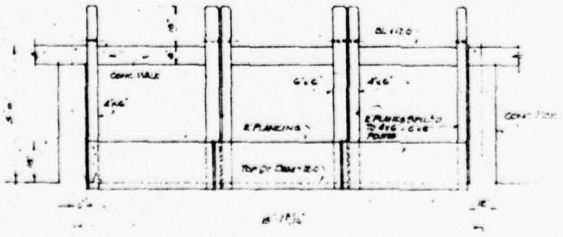


PLAN BELOW FLOOR

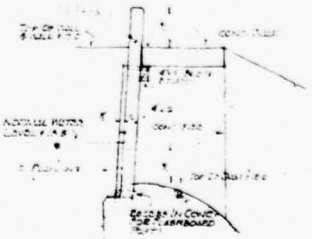
DETAILS OF CLEAN-OUT PIPE OPERATING PLATFORM



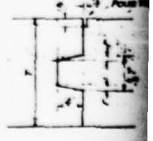
SECTION B-B



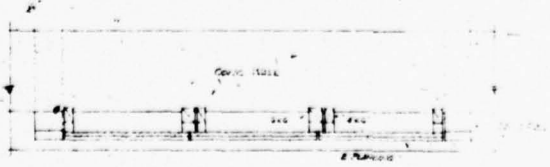
ELEVATION - UPSTREAM



SECTION

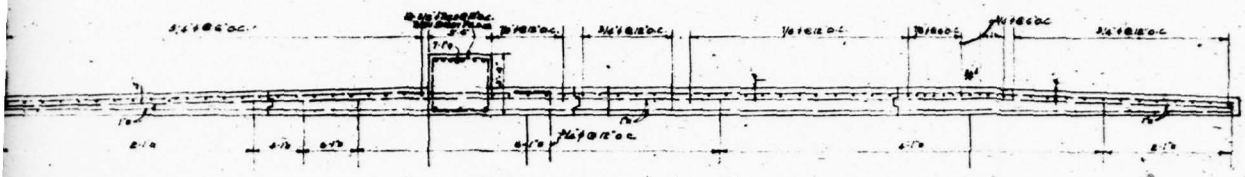


DETAIL OF JOINT



PLAN

DETAILS OF CONCRETE PARAPETS



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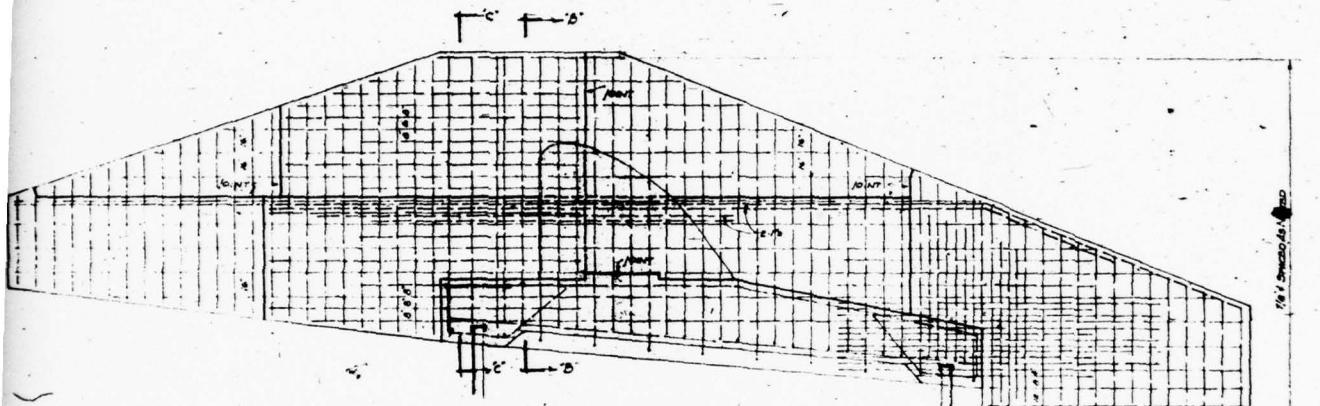
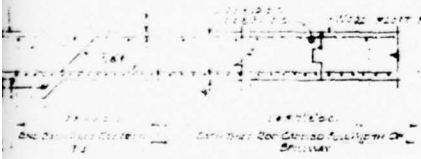
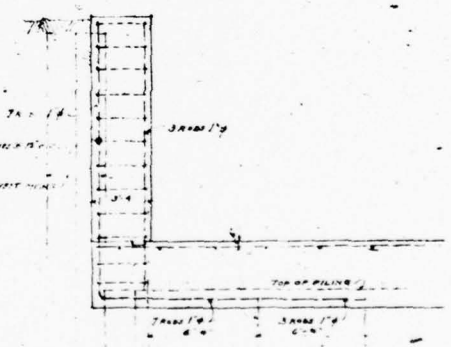


DETAIL OF ABUTMENT WALL REINFORCING FOR ALTERNATE "D" & "E"

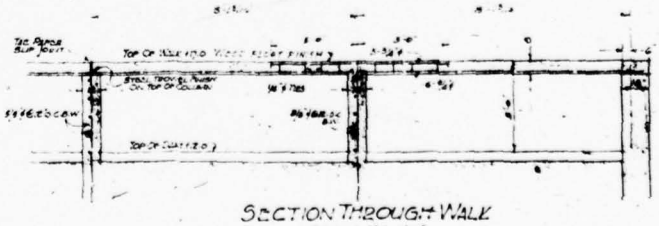
REINFORCING OF ABUTMENT WALLS FOR ALTERNATES A & C SIMILAR EXCEPT LENGTHS VARY TO SUIT ACTUAL DIMENSIONS.



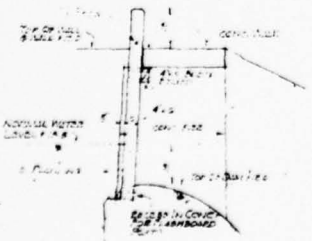
SECTION B-B



SECTION "CC"

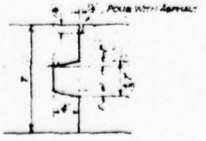


SECTION THROUGH WALK

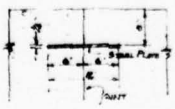


SECTION

DETAIL OF DOWEL SHEAR CONNECTORS



DETAIL OF JOINT



STEEL PLATE WATER STOP
USED ON ALTERNATES A & C

839

ALBRIGHT & FRIEL, Inc.
CONSULTING – ENGINEERS
PHILADELPHIA, PA.

SCALE AS NOTED	DOVER - DELAWARE
REVISIONS	SILVER LAKE DAM GENERAL DETAILS ALTERNATES A-B-C-D & E
DRAWN BY A.C.L.	APPROVED
TRACED BY	DATE JULY 7, 1958
	REGISTERED PROFESSIONAL ENGINEER
	PLAN NUMBER 44023-9

APPROVED
Gilbert R. Wilson
CITY ENGINEER

SILVER LAKE DAM
DOVER, DELAWARE

APPENDIX A

VISUAL INSPECTION CHECK LIST

Check List
Visual Inspection
Phase 1

Name Dam: Silver Lake County: Kent State: Delaware Coordinators: See below

Date(s) Inspection: 13 December 1977 Weather: Partly Cloudy Temperature: 35°F-40°F

Pool Elevation at Time of Inspection: 14.9 M.S.L. Tailwater at Time of Inspection: 3.8 M.S.L.

Inspection Personnel: Corps of Engineers, Philadelphia District

William H. Zink--Structures
David Erickson--Hydraulics and Hydrology
Robert W. Greene--Soils

William H. Zink--Recorder

Coordinators:

Mr. F. J. O'Neill City Engineer, City of Dover
Mr. D. VanZandt City Engineer's Staff, City of Dover

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	None
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed downstream. Upstream toe not inspected due to pool elevation.	None
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Sloughing of upstream embankment slope, left of overflow structure, appears to be result of wave action. Placement of ballast stone for corrective action--Summer 1976	Ballast stone appears ungraded and undersized. Recommend riprap with filter blanket--minimum 12-inch thick layer of riprap and 6-inch filter blanket.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Left crest appears uniform, both horizontally and vertically. Right crest varies in width (15-50 feet) and elevation. Saddle, approximately 1/2 foot lower than remainder of crest, evident at beach--parking area close to right abutment; area appears recently regraded	Saddle area may be beneficial as overflow location in the event of overtopping.
RIPRAP FAILURES	Stone protection along left upstream slope appears inadequate to prevent wave erosion.	Recommend formal riprap protection at erosion location; minimum 12-inch thickness of well graded stone and 6-inch filter blanket.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Overflow structure abutment/embankment junctions are severely eroded. Erosion appears to be the result of rainfall runoff on $2\frac{1}{2}$ H:1V unvegetated slope. Indications of remedial work being previously performed at these locations.	Recommend stabilizing of embankment slope in vicinity of overflow structure abutment walls. Suggest riprap for upstream slope and turfing downstream slope.
ANY NOTICEABLE SEEPAGE	Seepage noted along right section of embankment in drainage swale downstream of beach area. Seepage only noted entering from upstream bank facing reservoir; none on downstream bank. Seepage does not appear significant; no flow measurements available.	None.
STAFF GAGE AND RECORDER	Staff gage located on sluice gate platform is in need of replacement. Staff barely legible from embankment; not regularly read.	Recommend replacing staff gage and moving to more accessible location. Recommend readings be regularly obtained.
DRAINS	None observed or evident as part of the project construction.	None.

OUTLET WORKS (24-inch diameter cast iron pipe,
sluice gate and operating platform)

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Minor cavitation noted at outlet of 24-inch drawdown pipe. Outlet was formed from ogee structure at discharge end; pipe is cast iron except for the discharge.	No recommendations; cavitation appears minor
INTAKE STRUCTURE	Reportedly used annually to draw down lake about one foot for beach cleaning. Intake reported as operable but need diver to close gate; debris jams gate open. Too cold for dive; sluice gate not operated.	Recommend intake be cleaned and design formulated to prevent debris from entering gate seat; thereby, eliminating need for diver.
OUTLET STRUCTURE	24-inch diameter cast iron pipe not inspected; unable to examine due to pool elevation and ogee discharge.	None
OUTLET CHANNEL	Remedial stone protection previously placed using 4-inch nominal stone. Stone appears undersize and very poorly graded.	Recommend larger riprap layer, well-graded with filter blanket. Recommend straightening of discharge channel if erosion continues.
EMERGENCY GATE	Sluice gate and operating platform not examined due to reservoir pool elevation; platform accesible only by boat.	Recommend close inspection of platform and sluice gate by owner representatives during next drawdown; diver can perform underwater inspection

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Monolith joints appear to be in good condition, however, due to reservoir elevation, seepage cannot be determined. Numerous small popouts ($\frac{1}{2}$--3") in concrete surface evidenced by white water at holes. Second monolith from east contains two large holes, approximately 1-1$\frac{1}{2}$ feet horizontal, 2-3 inches wide, 10-12 feet from west monolith edge, 3 feet above bottom of ogee.	Recommend repair of concrete pop-out areas.
APPROACH CHANNEL	Deteriorated concrete at ice line--left abutment of overflow spillway structure	Deteriorated concrete at ice line should be repaired.
DISCHARGE CHANNEL	Both abutment walls have full length, top-to-bottom cracks downstream of the crest. Running water with efforescence visible; cracks partially healing. No noticeable wall movement observed. End of monoliths 3, 4, and 5 show some cavitation at joint with runout slab.	Cracks do not appear to affect the structural stability of the walls, however, cracks should be monitored for deterioration and material piping.
BRIDGE AND PIERS	Fifth bay from left bank has large longitudinal cracks in center of walkway, 4 & 5 feet in length, open approximately $\frac{1}{2}$-1 inch. Full length transverse crack at pier 6 and 10 feet left of pier 8. Some surface spalling on top walkway, between pier 11 and wall. Bars exposed (rusted) along west side of walkway--1$\frac{1}{2}$-inch diameter center steel exposed. South end of walkway between pier 2 and 3 badly cracked and spalled. Spalls average 2 per bay.	As bridge walkway is badly deteriorated, it should be repaired or replaced. Cavitation at pier-crest construction joint should be patched.

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	No instrumentation presently in use or planned for the project.	
OBSERVATION WELLS		
WEIRS		
PIEZOMETERS		
OTHER		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Upstream slope, left bank at approach wall severely eroded with 4-inch stone placed as riprap. See comments heretofore concerning embankment slopes. Rear slopes, $2\frac{1}{2}$H:1V, severally eroded behind both spillway abutment walls.	See previous recommendations.
SEDIMENTATION	City engineer indicates sedimentation studies not performed; no noticeable sedimentation of intake structure observed by owner representatives during annual drawdown.	None.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Downstream channel makes abrupt 45 degree bend immediately downstream of the ogee spillway. Bend will restrict flow during high discharges. Bridges at Division Street and Lockerman Street would constrict flow during flood releases.	Straightening of channel may be necessary if right bank cannot be stabilized.
SLOPES	Downstream area consists of parkland with very flat slopes to the stream banks. Parks are well sodded with very few obstructions.	None
APPROXIMATE NO. OF HOMES AND POPULATION	No homes are located within the flood plain downstream of the project. One structure, Treadway Towers, is subjected to inundation--Bottom floor of Treadway Towers contains a restaurant.	See recommendation to reclassify project to lower hazard category.
SAFETY TO PUBLIC	Spillway abutment walls present a falling hazard to the public. Spillway ogee presents a hazard to boaters in this area--particularly with respect to a steering failure of a motorboat close to the spillway crest or intake structure.	Safety hazards should be evaluated by the owner and appropriate action taken.

SILVER LAKE DAM

DOVER, DELAWARE

APPENDIX B

ENGINEERING, CONSTRUCTION,

MAINTENANCE DATA CHECK LIST

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	General plan of dam site shown on plan numbers 44023-4 dated 26 May 1944
REGIONAL VICINITY MAP	Map will be obtained from USGS quadrangle sheet for Dover, Delaware.
CONSTRUCTION HISTORY	Construction data is not available.
TYPICAL SECTIONS OF DAM	Majority of dam was constructed prior to 1900; no typical sections available. Sections in the vicinity of the spillway and former millrace are available on plan numbers 44023-2 and 44023-5 dated 7 July 1944.
HYDROLOGIC/ HYDRAULIC DATA	Stream gage data is available from U.S.G.S. for the period 1958 to the present. No hydrologic data, other than drainage area, available. Spillway rating curve is available on plan numbers 44023-4 dated 7 July 1944.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	Construction plan and details of the 24-inch diameter cast iron pipe are available on plan numbers 44023-5 and 44023-9 dated 7 July 1944.
RAINFALL/RESERVOIR RECORDS	No rain gage is maintained in the project drainage area, no accurate records available. No reservoir records maintained.

ITEM	REMARKS
DESIGN REPORTS	Downstream Flood Hazard Report; Federal Insurance Administration, City of Dover dated 22 July 1977, see Appendix G.
GEOLOGY REPORTS	No geology reports available; boring logs shown on plan numbers 44023-4 dated 7 July 1977.
DESIGN COMPUTATIONS	No design computations available for original contract plans.
HYDROLOGY & HYDRAULICS	See paragraph 9 of report.
DAM STABILITY	No original dam stability analysis available.
SEEPAGE STUDIES	No original seepage studies avaiable.
MATERIALS INVESTIGATIONS	No material tests available.
BORING RECORDS	Boring logs available; plan numbers 44023-4.
LABORATORY	No laboratory or field results available.
FIELD	
POST-CONSTRUCTION SURVEYS OF DAM	No post-construction surveys have been obtained--recommend centerline elevation survey, at minimal , for documentation of present condition.
BORROW SOURCES	Borrow source unknown; assumed to be in close proximity to embankment--possibly from downstream right abutment.
SPILLWAY PLAN	
SECTIONS	Contained in plan number 44023-5 dated 7 July 1944.
DETAILS	Reinforcing and forming details contained in Contractor's shop drawings numbered 6367; not included in report due to very poor reproduction quality.
OPERATING EQUIPMENT PLANS & DETAILS	No plan of operations has been formulated for the Silver Lake Project. Recommend formulation.

ITEM	REMARKS
MONITORING SYSTEMS	No monitoring systems presently in use at the project site. Staff gage on intake tower is illegible; reoommend replacement and relocation to more accessible location. Recording USGS stream gage located 1950 feet downstream of project site.
MODIFICATIONS	Original project, constructed prior to 1900, was modified in 1944 after failure of the original spillway structure. Reconstruction encompassed construction of an overflow structure and filling of the former millrace location.
HIGH POOL RECORDS	No pool records are maintained for the reservoir. No monitoring of reservoir elevation during heavy rainfall or rising pool.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None None on dam construction. Flood hazard report prepared for downstream area.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	See previous comments; original overflow spillway failed in 1943. No report or specific information on failure is available. No contingency warning system presently in effect.
MAINTENANCE OPERATION RECRODS	See previous comments. Maintenance presently performed on an as-needed basis.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 32 square miles

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 590 acre-feet at elev. 14.4

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1,835 acre-feet at elevation 20.0

ELEVATION MAXIMUM DESIGN POOL: Not available

ELEVATION TOP DAM: 19.4 feet s.l.d.

CREST: Overflow structure

a. Elevation: 14.4 feet s.l.d.
b. Type: Uncontrolled concrete ogee gravity structure
c. Width: Not applicable
d. Length: 150 feet
e. Location Spillover: Discharge over 150 foot width
f. Number and Type of Gates: Ungated 10 bays at 15 feet/bay

OUTLET WORKS: 24-inch cast iron pipe with sluice gate and operating platform

a. Type: Cast iron 24-inch diameter pipe
b. Location: Third bay from east wall through overflow structure
c. Entrance inverts: +4.4 feet s.l.d.
d. Exit inverts: +4.4 feet s.l.d.
e. Emergency draindown facilities: sluice gate for 24-inch C.I. pipe

HYDROMETEOROLOGICAL GAGES: U.S.G.S. Stream gage

a. Type: Water-stage recording gage--U.S.G.S.
b. Location: 1,950 feet d.s. of project
c. Records: 1958 to present

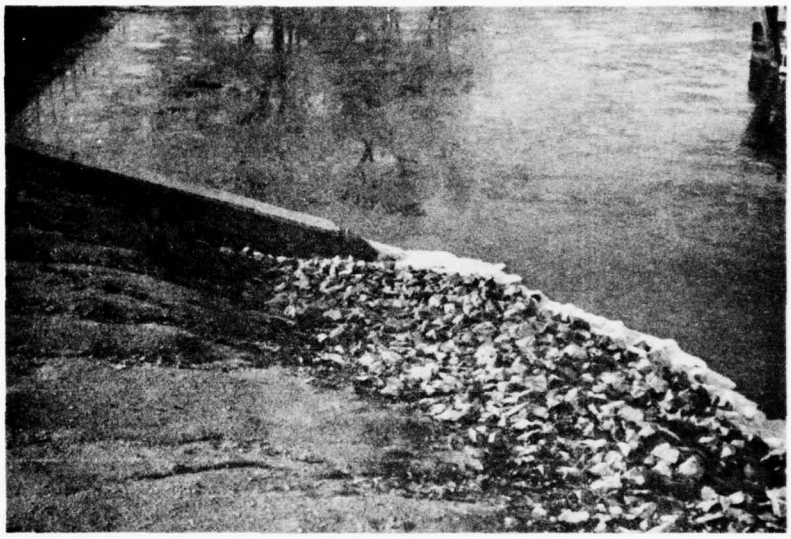
MAXIMUM NON-DAMAGING DISCHARGE: Non-existant

SILVER LAKE DAM

DOVER, DELAWARE

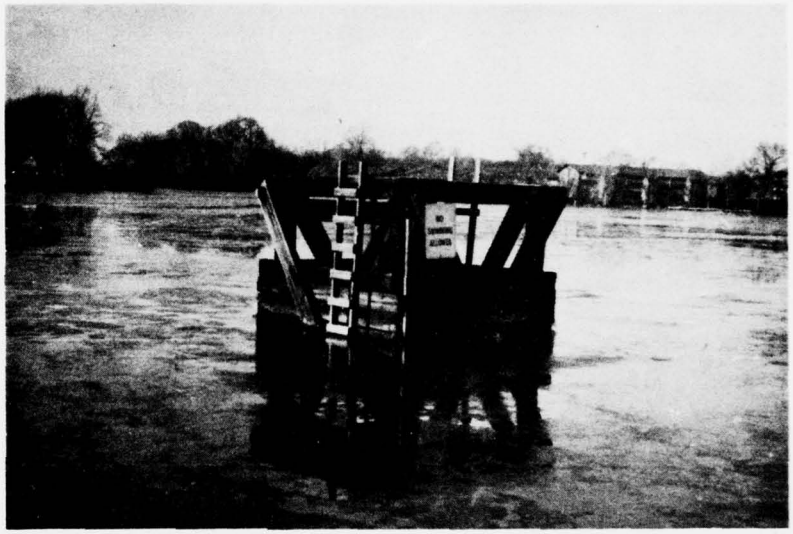
APPENDIX C

PHOTOGRAPHS

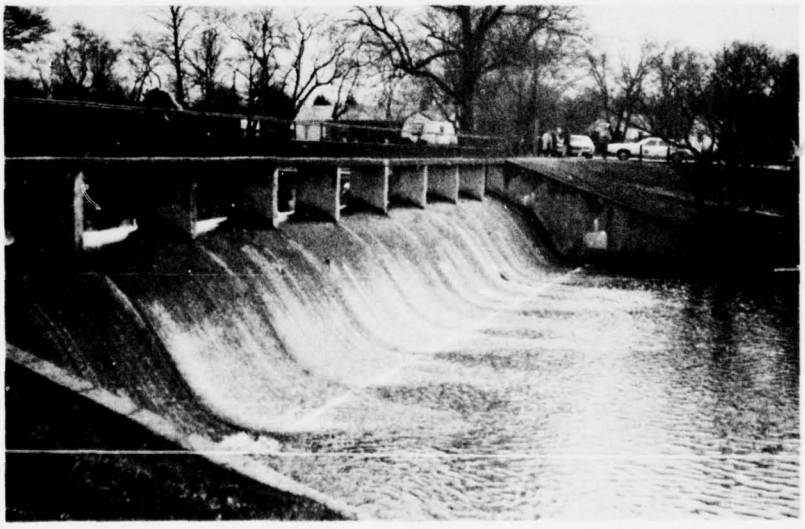


1. 13 Dec 77. Upstream embankment slope behind overflow structure left abutment wall. Note sloughing of embankment, 4" remedial stone, and deterioring concrete at freeze-thaw line.

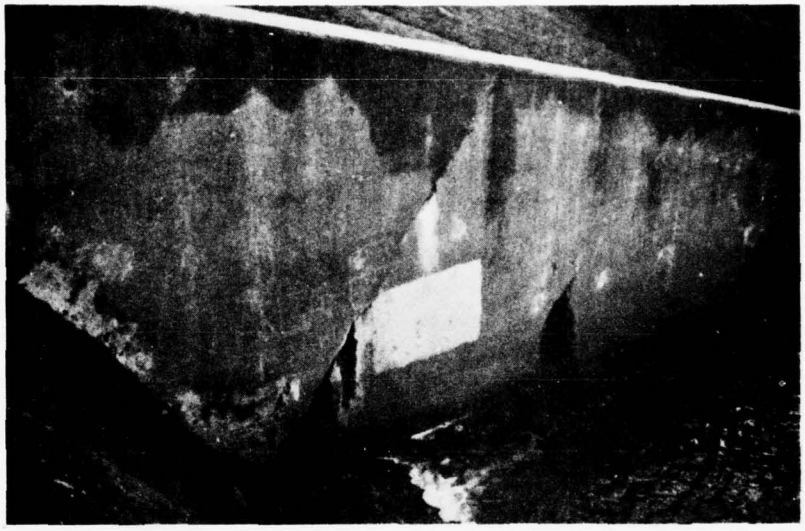
2. 13 Dec 77. Downstream right abutment drainage swale, looking southeast toward confluence with St. Jones River.



3. 13 Dec 77. View of sluice gate operating platform. Photo from left abutment area looking north toward upstream reservoir area.



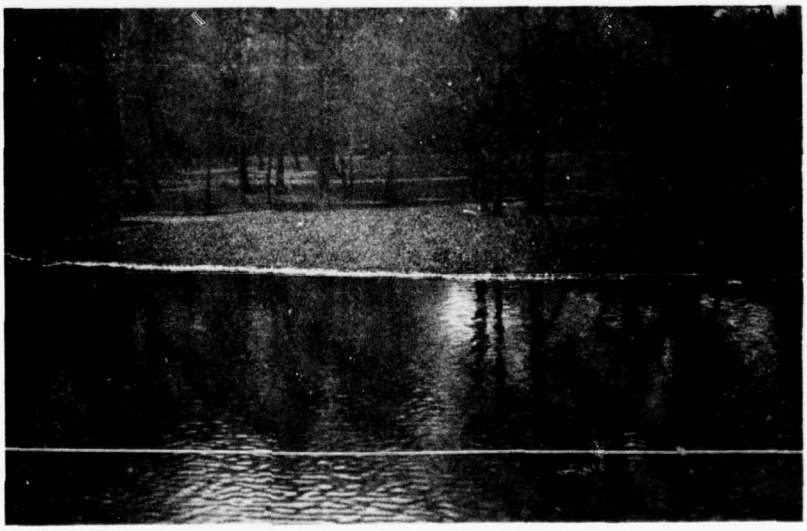
4. 13 Dec 77. Overview of concrete gravity overflow structure, looking east from right abutment wall toward left abutment wall.



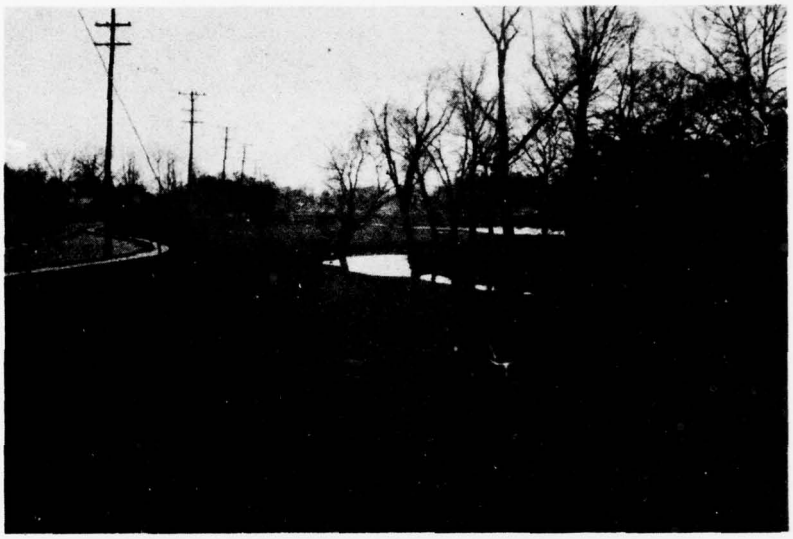
5. 13 Dec 77. Close view of overflow structure left abutment wall showing diagonal cracking with minor leakage, looking southeast from walkway.

6. 13 Dec 77. Longitudinal cracking of overflow structure walkway - fifth bay from left bank.

7. 13 Dec 77. Spalled concrete at pedestal/ogee crest construction joint.



8. 13 Dec 77. Downstream right bank erosion area and 4" stone remedial measures.



9. 13 Dec 77. Downstream floodplain area looking south from project site toward Division Street Bridge.

SILVER LAKE DAM

DOVER, DELAWARE

APPENDIX D

HYDRAULICS/HYDROLOGIC ANALYSIS

APPENDIX D

HYDRAULICS/HYDROLOGIC ANALYSIS

In accordance with criteria set forth for the Phase I hydraulic and hydrologic analysis of dams, Silver Lake was evaluated for two major items:

1. Drawdown time of the reservoir in the event of impending structural failure.

2. Dam overtopping potential in the event of a designated flood.

The evaluations are based on data obtained during the field inspection of the project and on supplemental data developed in the absence of available data.

Emergency Drawdown of Lake

The outlet works system of Silver Lake consists of a sluice-gated 24-inch diameter cast iron pipe approximately 59 feet long. Invert elevations of the pipe are 4.4 feet S.L.D. at both the intake and discharge ends. Since no outlet works rating curve is available, one was developed using basic hydraulic theory and conservative friction losses. The results of the hydraulic analysis indicates that the outlet works pipe will allow 55 cfs flow at normal pool (elevation 14.4 feet S.L.D.) and 68 cfs flow at top of dam (elevation 19.4 feet S.L.D.). Under emergency conditions when the structural integrity of the dam dictates lowering of the reservoir, 10 days would be required to coupletely evacuate the pool under normal inflow conditions. Under flood conditions, the amount of water which could be released through the outlet works pipe is considered insignificant in comparison with the total release.

Overtopping Potential

In accordance with recommendations contained herein, Silver Lake is classified as having a significant hazard potential with respect to loss of human life or property damage in the area downstream of the dam in the event of failure. Under this classification, a small dam should be capable of safely passing a spillway design flood in the 100-year to one-half of the probable maximum flood ($\frac{1}{2}$ PMF) range.

The overflow structure of the Silver Lake dam consists of a concrete gravity ogee-shaped wall, 150 feet wide with a crest elevation of 14.4 feet S.L.D. The top of dam elevation, 19.4 feet S.L.D., is five feet above spillway crest. From project design data, a spillway rating curve was availabe for elevations 14.4 S.L.D. to 18.4 S.L.D. and extrapolation of the curve to

the top of dam elevation 19.4 S.L.D. indicates that the maximum spillway discharge is 5,100 cfs.

The methodology used to determine the design floods was by use of the unit hydrograph in conjunction with frequency/design precipitation. This method develops both a peak inflow value and an inflow hydrograph adaptable to reservoir routing.

In an attempt to comply with Phase I hydrologic evaluation criteria, unit hydrographs were developed using the Soil Conservation Service "Triangular Method" as presented in U. S. Department of Interior-Bureau of Reclamation publication titled "Design of Small Dams".

Precipitation information for the probable maximum precipitation and the 100 year precipitation was obtained from U. S. Department of Commerce-Weather Bureau publication "Technical Paper No. 40-Rainfall Frequency Atlas of the United States, May 1961." The precipitation data was developed and incorporated within an interactive computer program "UHCOMP" written and maintained by the Hydrologic Engineering Center, Davis, California. This program develops the flood hydrograph for the design floods from input of drainage area, precipitation, loss rates, and unit hydrograph. For the possible maximum precipitation the program develops the rainfall distribution; while for the 100 year precipitation event the distribution must be independently developed.

The design floods for the Silver Lake project, as developed by the above methodology, have peak values as follows:

$\frac{1}{2}$ PMF = 37,385 cfs.

100 year = 14,562 cfs.

The values for the $\frac{1}{2}$ PMF were obtained by halving the PMF discharge values. To analyze the potential for overtopping during the design floods of 100 year and 1/2 PMF magnitude the inflow hydrographs for those events were routed through the reservoir by use of an interactive reservoir routing computer program maintained by the Hydraulics and Hydrology Branch of the Philadelphia District. Inflow hydrograph, elevation vs. capacity table and spillway rating table are the program's input while outflow hydrograph and pool elevation data are the output.

As no elevation vs. capacity table was available during the inspection, it was necessary to develop one. The elevation vs. capacity curve was developed by a straight line relationship between top of dam capacity and normal pool capacity.

The results of the routings of the 100 year and 1/2 PMF magnitude flood hydrographs indicate that the spillway is not capable of passing either of these design floods without the dam being overtopped. The routings do not indicate the amount of overtopping, but only that it will occur.

DAM SAFETY
SILVER LAKE DAM, DELA.

Unit Hydrograph (See Triangular)

Length — L: 7.6 mi.
Elevation Difference — H: 58 ft (72-14)
Drainage Area: DA: 38 mi²

$$T_c = \left(\frac{11.9\ L^3}{H}\right)^{.385} = 5.7$$

Use D = 1 HR

$$T_p = D/2 + .6(T_c)$$

$$T_p = 3.9$$

$$q_p = \frac{484\ A(Q)}{T_p} = \frac{484\ (38)(.1)}{3.9}$$

$$q_p = 3770$$

Triangular U.H. mid-feet & curvilinear U.H.

Time	T/T_p	q/q_p	q Approx	q
1	.25	.12	476	467
2	.51	.45	1790	1760
3	.76	.89	3310	3270
4	1.02	1.00	3970	3900
5	1.28	.86	3410	3350
6	1.53	.63	2500	2450
7	1.79	.42	1670	1640
8	2.05	.30	1190	1170
9	2.30	.21	834	818
10	2.56	.15	590	579
11	2.82	.094	373	366
12	3.07	.070	278	273
13	3.33	.055	218	214
14	3.58	.034	135	132
15	3.84	.024	95	93
16	4.10	.016	64	63
17	4.35	.012	48	47
18	4.61	.008	32	31
19	4.87	.005	20	20
20	5.10	.003	12	12
			21085	21056 cfs

$\frac{21085}{20650} = .98$

SILVER LAKE
DOVER DELAWARE

DRAINAGE AREA = 32 S.M.'s

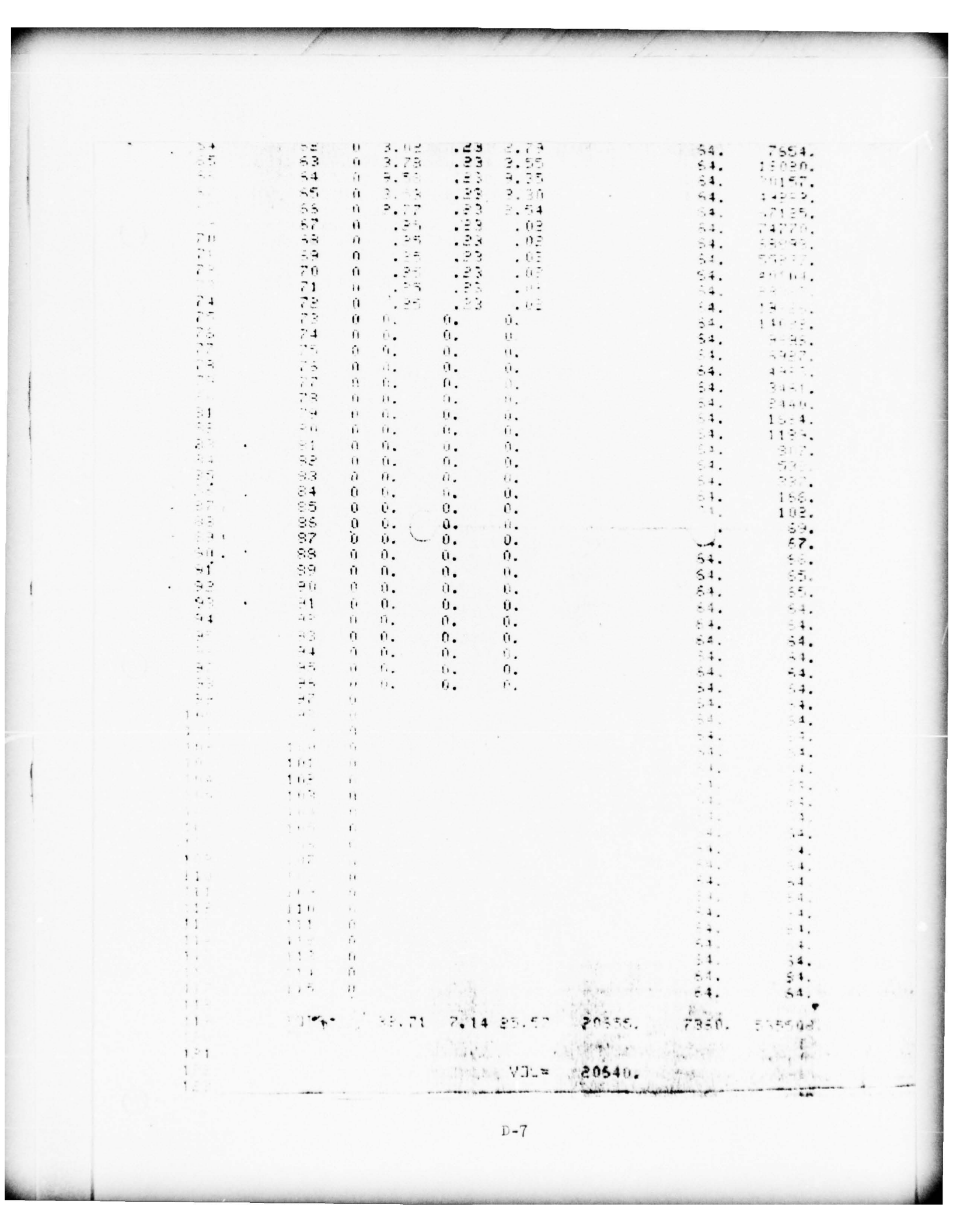
Pool Elevation		Height Above Crest		Acre-Ft.
14.4		0	590	0
14.9		0.5		125
15.4		1.0		249
15.9		1.5		374
16.4		2.0		498
16.9		2.5		623
17.4		3.0		747
17.9		3.5		872
18.4		4.0		996
18.9		4.5		1121
19.4	Top of Dam	5.0	1835	1245
20		5.6		1400
22		7.6		1903
24		9.6		2300
30		15.6		3500

Pool Elev. vs. Discharge & Storage Table

Elev.	Discharge (CFS)	Storage (Ac-Ft)
14.4 (Spillway Crest)	0	0
14.9	148	125
15.4	455	249
15.9	870	374
16.4	1370	498
16.9	1910	623
17.4	2510	747
17.9	3150	872
18.4	3780	996
18.9	4400	1121
19.4 Top of Dam	5100	1245
20	6100	1400
22	9400	1900
24	13200	2300
30	31000	3500

```
UNIT GRAPH AND HYDROGRAPH COMP JULY 1966 (REVISED MARCH 1978)
HYDROLOGIC ENGINEERING CENTER (HEC)
DAVIS,CA


--- OPERATIONS AVAILABLE ---

TIME INT = SET TIME INTERVAL OF ALL COMPUTATIONS
UNIT H   = COMPUTE UH BY INPUT, CLARK, SNYDER
RAIN     = INPUT RAIN AND LOSS RATE DATA
RUNOFF   = INPUT EXCESS, COMPUTE & PRINT HYDROGRAPH
PRINT    = PRINT UNIT HYDROGRAPH ORD
STOP     = STOP EXECUTION OF PROGRAM

                  ( 1) OPERATION DESIRED
                  ( 2) NO. OF ORDINATES

                  INTERVAL (MIN) = 60

                  (1=TIME INT, 2=UNIT HY, 3=RAIN, 4=RUNOFF, 5=PRINT, 6=STOP) 1
                  DRAINAGE AREA (SQMI) = 32.0
                  (1=INPUT ORD, 2=CLARK, 3=SNYDER) 1
                  NO OF ORDINATES = 20
                  ORD = 487 1740 3870 2900 2350 2450 1640 1120 810 574
                        428 317 231 170 125

                  (1=TIME INT, 2=UNIT HY, 3=RAIN, 4=RUNOFF, 5=PRINT, 6=STOP) 3
                  INTERVAL (IN) = .1
                  (1=INIT+CONST, 2=SCS, 3=HOLTAN) 1
                  INITIAL LOSS (IN) = 33.0
                  CONSTANT LOSS (IN/HR) = 33.
                  NO. OF ORDINATES = 30 97 117 117 117
                  SCS TABLE (SQMI) = 1.32
                  (1=INIT+CONST, 2=SCS, MOIST LOSS) 1
                  INITIAL LOSS (IN) CONSTANT LOSS (IN/HR) = 1.00

                  (1=TIME INT, 2=UNIT HY, 3=RAIN, 4=RUNOFF, 5=PRINT, 6=STOP) 4
                  STORM
                  (1=
                  (1=TIME INT, 2=UNIT HY, 3=RAIN, 4=RUNOFF, 5=PRINT, 6=STOP) 1
                  POWER LAW DELMARVA FULL PMP
                  (1=
                  64 0 1
                  INTERVAL (MIN) = 60

                  (1=TIME INT, 2=UNIT HY, 3=RAIN, 4=RUNOFF, 5=PRINT, 6=STOP) 5
                  PRINT UNIT HYDROGRAPH ORDINATES
                  (1=
                  (1=TIME INT, 2=UNIT HY, 3=RAIN, 4=RUNOFF, 5=PRINT, 6=STOP) 6
                  STOP EXECUTION OF PROGRAM
                  (1=
```

Silver Lake Dam, Delaware
PMF



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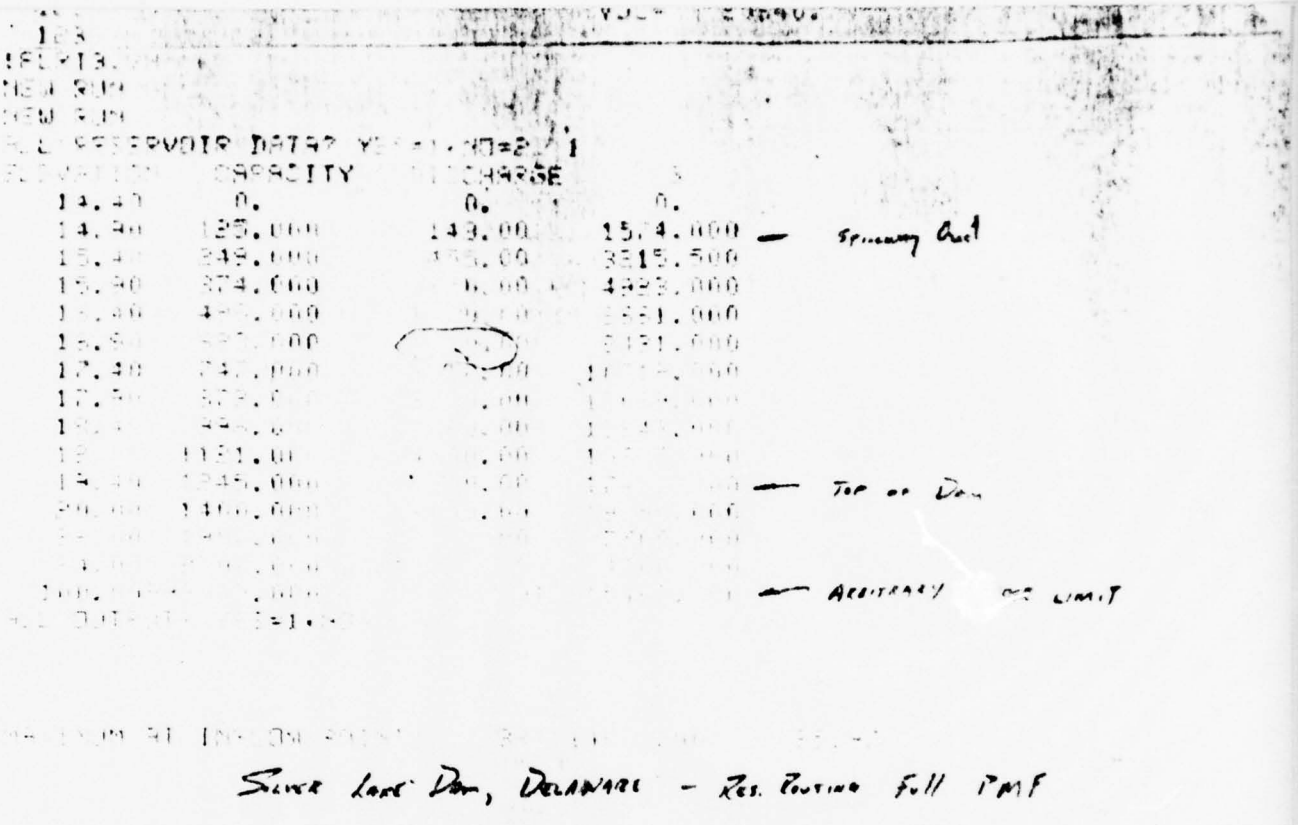

Silver Lake Dam, Delaware - Res. Routing Full PMF

D-8

	311.	15.94	[illegible]
15 376.	775.	15.73	[illegible]
16 [illegible]	675.	15.67	315.340
17 [illegible]	607.	15.59	[illegible]
18 411.	560.	15.53	[illegible]
19 434.	530.	15.49	[illegible]
508.	523.	15.48	[illegible]
20 734.	573.	15.54	[illegible]
1139.	706.	15.70	[illegible]
1544.	[illegible]	[illegible]	[illegible]
[illegible]	1536.	[illegible]	[illegible]
2140.	1567.	16.57	[illegible]
3444.	2167.	17.11	[illegible]
7554.	4045.	18.63	1054.135
22 16030.	3067.	21.77	1343.497
[illegible]	14990.	24.09	[illegible]
[illegible]	13274.	24.31	5487.536
[illegible]	13354.	24.55	10911.810
24770.	13446.	25.05	15025.033
[illegible]	13542.	25.40	[illegible]
[illegible]	13554.	25.55	[illegible]
[illegible]	13564.	25.55	[illegible]
[illegible]	13561.	25.93	[illegible]
19736.	13560.	25.96	[illegible]
14082.	13560.	25.97	[illegible]
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[illegible]	13544.	25.90	[illegible]
[illegible]	13554.	25.94	[illegible]
[illegible]	13514.	25.79	[illegible]

Equations above 240 for acid nuclid

		13514.	25.78	25343.054
43	2440.			
		13400.	25.71	24712.379
44	1654.			
		13582.	25.83	23718.455
45	1189.			
		13564.	25.55	22694.465
46	807.			
		13545.	25.47	21894.149
47	588.			
		13525.	25.38	20741.101
48	337.			
		13506.	25.31	19440.999
49	155.			
		13486.	25.	18[illegible]2.059
50	102.			
		13466.	25.14	17317.543
51	52.			
		13446.	25.05	16101.443

		13427.	24.97	14987.340
52	54.			
		13407.	24.88	13879.304
53	49.			
		13387.	24.80	12764.337
54	36.			
		13367.	24.71	11699.020

	0.	0.	0.
14.40	135.000	140.00	1874.000
	249.000	455.00	3215.500
	374.000	670.00	4333.000
14.40	498.000	1370.00	5551.000
14.50	583.000	1410.00	8431.000
14.40	747.000	2510.00	10319.000
14.50	878.000	3160.00	12039.000
14.40	996.000	3780.00	13343.000
14.50	1191.000	4300.00	15559.000
14.40	1345.000	5100.00	17450.000
14.50	1400.000	6100.00	19350.000
14.50	1900.000	9400.00	27510.000
14.50	2700.000	13800.00	34200.000
14.50	4[illegible]4.000	21000.00	42[illegible]4.000

[illegible]

ALL OUTPUT YES=1.0 ?

MAXIMUM AT INFLOW POINT 35 14179.00 84.47

Silver Lake Dam Drainage - Reservoir Routing of 1/2 PMF

	98.			
		3.	14.41	2,541
	99.			
		7.	14.42	5,161
	56.			
		11.	14.44	8,173
1	101.			
		19.	14.47	16,835
	980.			
		49.	14.54	35,403
	802.			
		95.	14.72	80,395
	1015.			
		215.	15.01	153,069
3	1220.			
		401.	15.32	285,005
4	1115.			
		560.	15.53	398,775
6	949.			
		685.	15.68	305,286
11	715.			
		830.	15.81	301,805
13	443.			
		934.	15.93	988,099
7	315.			
		990.	15.43	868,534
1	139.			
		1113.	15.40	249,030
1	169.			
		1144.	15.31	896,114
1	130			
		1155.	15.34	108,573
1	144.			
		1225.	15.19	157,777
1	207.			
		1304.	15.11	183,529
	217.			
		1384.	15.13	181,934
2	201.			
		1388.	15.19	179,033
2	249.			
		1397.	15.14	135,139
2	200.			
		1434.	15.22	165,076
2	290.			
		1431.	15.34	233,125
3	450.			
		1481.	15.50	240,472

		561.	15.53	[illegible]
28	1145.			
		703.	15.70	[illegible].713
29	1747.			
		973.	16.00	[illegible].472
27	3827.			
		1519.	16.82	[illegible]2.048
	5010.			
		3345.	18.93	1029.345
	15075.			
		5514.	21.47	1755.585
30	24511.			
		13211.	24.0[illegible]	2912.055
31	33563.			
		13241.	24.13	4506.902
32	37385.			
		13277.	24.33	6617.294
33	37815.			
		13293.	24.42	7311.371
	[illegible]0052.			
		[illegible]	[illegible]	[illegible]
	[illegible]			
		[illegible]	[illegible]	[illegible]
	[illegible]			
		[illegible]	24.34	[illegible]
	[illegible]			
		[illegible]	24.40	[illegible]
	[illegible]			
		[illegible]	24.38	[illegible]
		[illegible]	[illegible]	[illegible]
		[illegible]	24.23	5136.471
		[illegible]	24.14	[illegible]
		[illegible]	24.07	[illegible]
		[illegible]	23.48	[illegible]
		[illegible]	21.55	1795.277
		5610.	19.41	1346.618
		[illegible]	18.08	915.515
		[illegible]	17.19	635.097
		1564.	16.55	549.755
		1117.	16.15	435.314
		[illegible]	15.80	357.886
		624.	15.51	300.451

Elevations above 24.0 feet are invalid

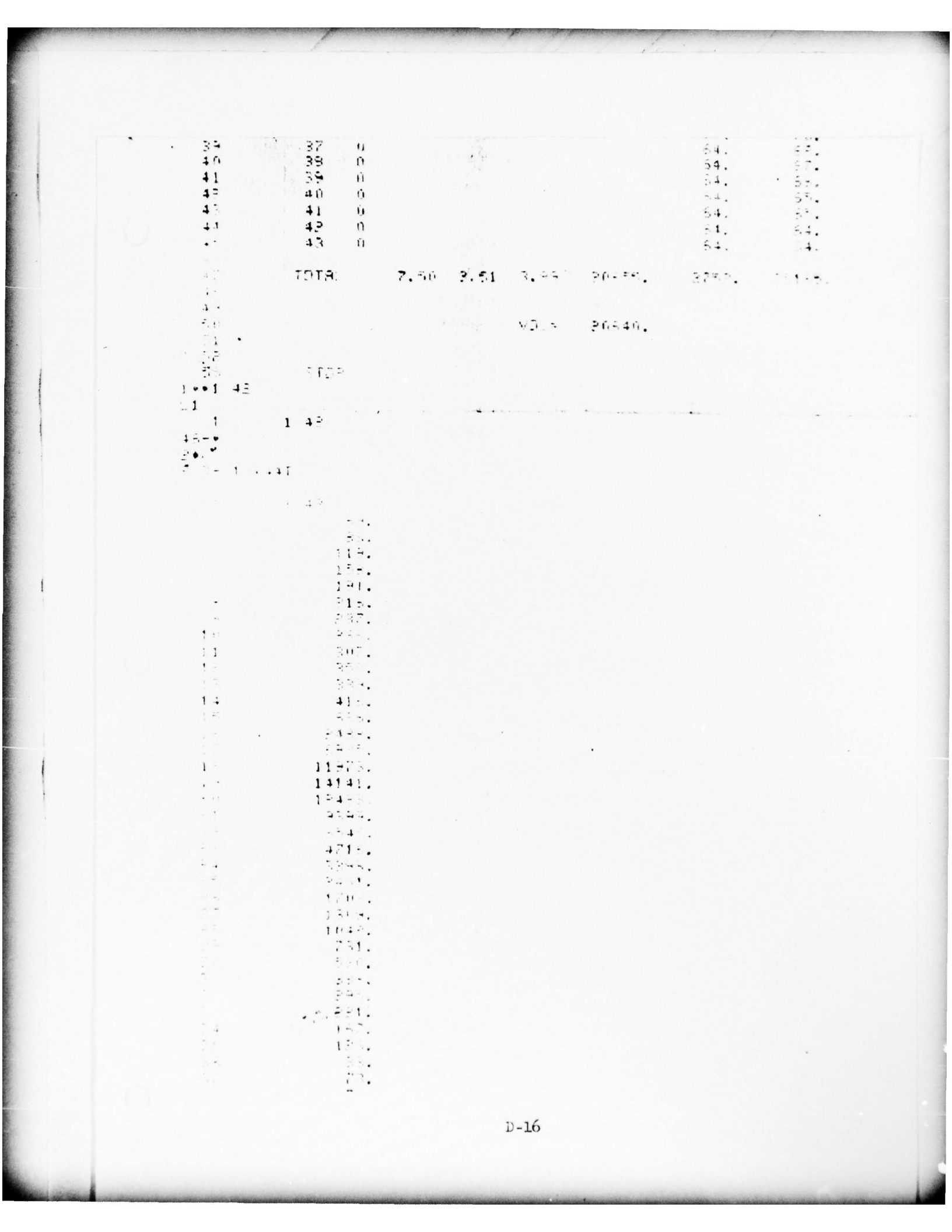
OUTFLOW	ELEVATION	CONTENT
4[illegible].	15.43	197.05[illegible]
[illegible].	15.30	[illegible]
[illegible].	15.19	[illegible]
270.	15.10	174.107

```
12/29/77
09:48:18
```

```
FILES, STRID, DISCN, AND PTIOS = 64 0 1
SELECT 1-6 (1=TIME INT, 2=UNIT H, 3=PRINT, 4=PUNOFF, 5=PNT, 6=STOP) 6
CRUISE:1.5
!SWITCH OUT$.

!SWITCH .CLOSE
SPS302 W CLOSE/REW OF ORIGINAL ISNOPEN
!SWITCH .CLOSE
SPS302 W CLOSE/REW OF ORIGINAL ISNOPEN
!SWITCH. CLOSE
SPS198 E SWAPPR NOT PERMITTED
!SWITCH OUTF .CLOSE
SPS198 E OUTF  -ERR OPEN AT OUTF
!SWITCH OUTF$:.CLOSE
!EXIT
```

	1	0	.10	.09	.01	450.	64.
	2	0	.10	.09	.01	1700.	64.
	3	0	.10	.09	.01	2270.	64.	113.
	4	0	.10	.09	.01	3300.	64.	155.
	5	0	.10	.09	.01	3350.	64.	191.
	6	0	.10	.09	.01	2450.	64.	216.
	7	0	.20	.18	.02	1440.	64.	232.
	8	0	.20	.18	.02	1170.	64.	256.
	9	0	.20	.18	.02	910.	64.	302.
	10	0	.20	.18	.02	579.	64.	352.
	11	0	.20	.18	.02	355.	64.	394.
	12	0	.20	.18	.02	273.	64.	416.
	13	0	.20	.27	.43	214.	64.	429.
	14	0	.10	.27	2.53	139.	64.	2482.
	15	0	.20	.27	.43	93.	64.	2930.
	16	0	.20	.18	.02	59.	64.	11473.
	17	0	.20	.18	.02	47.	64.	14141.
	18	0	.20	.18	.02	31.	64.	12458
	19	0	.10	.09	.01	20.	64.	8208.
	20	0	.10	.09	.01	12.	64.	5745.
	21	0	.10	.09	.01		64.	4716.
	22	0	.10	.09	.01		64.	3948.
	23	0	.10	.09	.01		64.	3441.
	24	0	.10	.09	.01		64.	1703.
	25	0					64.	1401.
	26	0					64.	1015.
	27	0					64.	731.
	28	0					64.	530.
	29	0					64.	385.
	30	0					64.	280.
	31	0					64.	203.
	32	0					64.	147.
	33	0					64.	106.
	34	0					64.	77.
	35	0					64.	56.
	36	0					64.	40.
	37	0					64.	29.

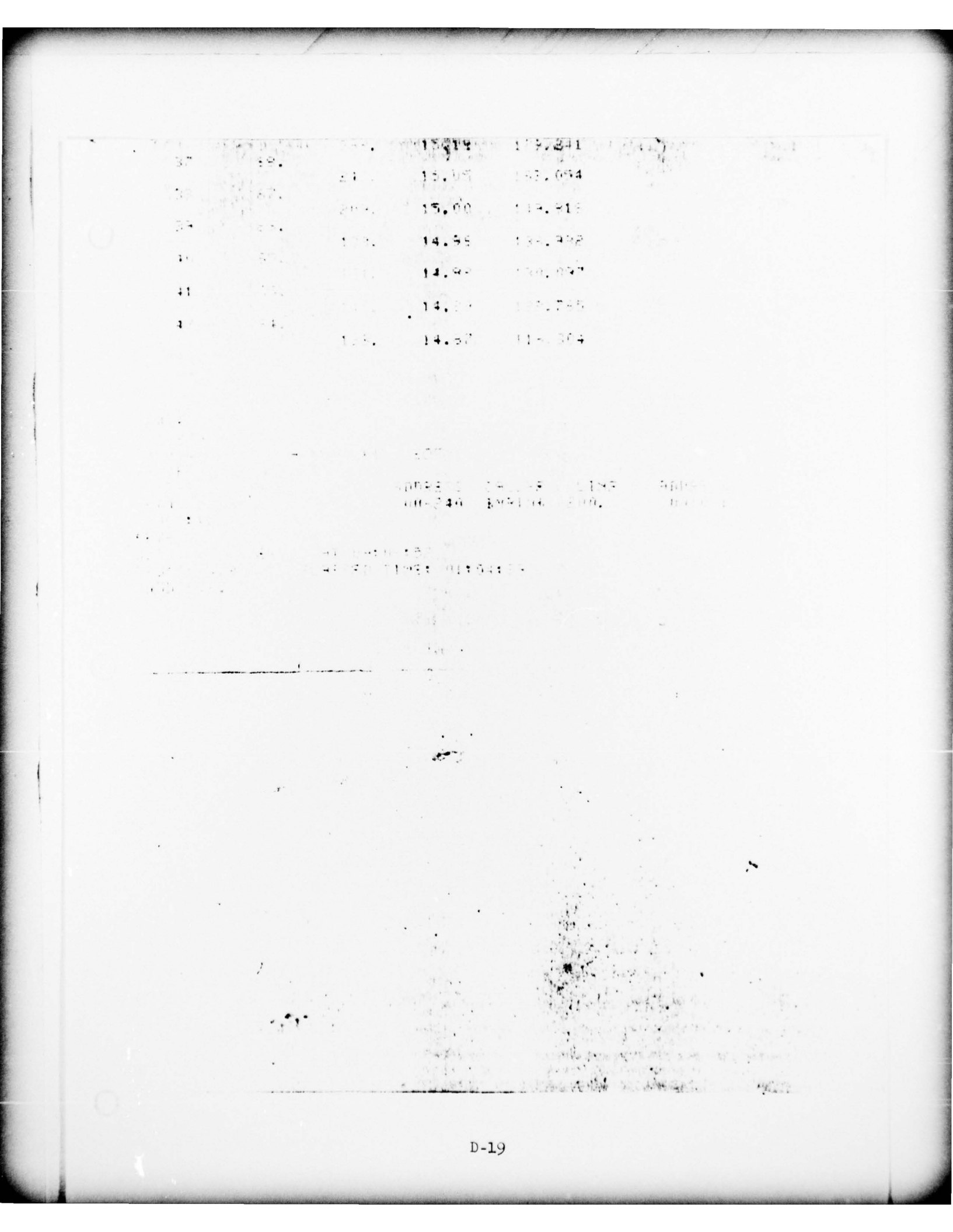


38	70.
39	69.
40	67.
41	65.
42	63.
43	61.
44	59.
45	58.

14.40	0.	0.	0.
14.44	135.000	135.00	1574.000
15.00	248.000	405.00	3915.500
15.40	374.000	870.00	6457.000
15.90	448.000	1320.00	8551.000
16.40	623.000	1910.00	8431.000
16.40	747.000	2510.00	10213.000
17.00	872.000	3150.00	12038.000
18.40	996.000	40.00	13842.000
18.90	1121.000	4400.00	15552.000
19.40	1245.000	5100.00	17490.000
20.00	1400.000	6100.00	19850.000
22.00	1900.000	9400.00	27500.000
24.00	3300.000	16000.00	34510.000
30.00	4444.000	21000.00	45450.000

14.	14.43	5.4
14.	14.44	11.74
24.	14.45	20.13
34.	14.53	30.790
51.	14.57	48.063
57.	14.62	56.153
43.	14.63	43.703
100.	14.74	94.373

		100.	14.74	54.378
9	307.			
		113.	14.80	100.734
10	358.			
		141.	14.88	119.919
11	389.			
		191.	14.95	138.201
12	416.			
		225.	15.02	154.445
13	445.			
		269.	15.15	187.741
14	571.			
		809.	15.83	355.441
	7155.			
		8741.	17.69	511.384
	12430.			
		8405.	20.15	1445.814
	14723.			
		10078.	22.35	1979.464
	14874.			
		11670.	22.19	1151.381
	5446.			
		10550.	22.41	2031.024
	6758.			
		8454.	21.54	1734.498
	4451.			
		7004.	20.55	1737.455
	3500.			
		5504.	19.64	1307.345
	2915.			
		4764.	18.85	1103.535
	1751.			
		3445.	18.13	930.249
	1345.			
		2714.	17.54	794.733
	1067.			
		2141.	17.10	670.554
	748.			
		1700.	16.71	574.343
	549.			
		1343.	16.38	439.430
	344.			
			16.10	331.429
			15.93	
			15.78	
			15.64	144
			15.41	251.688
			15.23	189.983
			15.11	141.345
			15.	241



SILVER LAKE DAM

DOVER, DELAWARE

APPENDIX E

ENGINEERING, CONSTRUCTION
AND
OPERATIONAL DATA

APPENDIX E

ENGINEERING, CONSTRUCTION AND OPERATIONAL DATA AND ANALYSIS

Availabe engineering and construction data was used to determine the structural stability and seepage potential of the Silver Lake overflow structure and abutment walls. The analyses were determined in accordance with Corps of Engineers Manuals and Technical Letters concerning flood wall design, retaining walls, gravity dam design and gravity dam design stability. A brief explanation of the analyses is as follows:

Seepage. A cursory seepage analysis behind and under the overflow structure abutments was conducted using the Creep Ratio Method. Several seepage paths were analyzed using the sheet piling behing the wall as a portion of the paths behind the walls while neglecting the sheet piling under the abutment for this path. In all cases, the computed Creep ratios were greater than normally accepted minimums for the materials involved.

Stability. The stability analysis was made for sliding resistance and overturning. In the interest of conservativism, the sheet piling was neglected thereby subjecting the wall to full uplift. The headwater elevation was assumed at ogee crest, elevation 14.4, and the ϕ angle at 33 degrees. The analysis shown hereafter, indicates that the gravity structure is stable from both a sliding and overturning stand point. The factor of safety for sliding was computed as 1.5 based on the conservative analysis and the overturning resultant was computed as occurring 7.24 feet from the upstream base end.

BY R.C.B. DATE 5 JAN 79 SUBJECT SILVER LAKE DAM SHEET NO. 1 OF
CHKD. BY DATE DAM INSPECTION JOB NO.

REFERENCES:

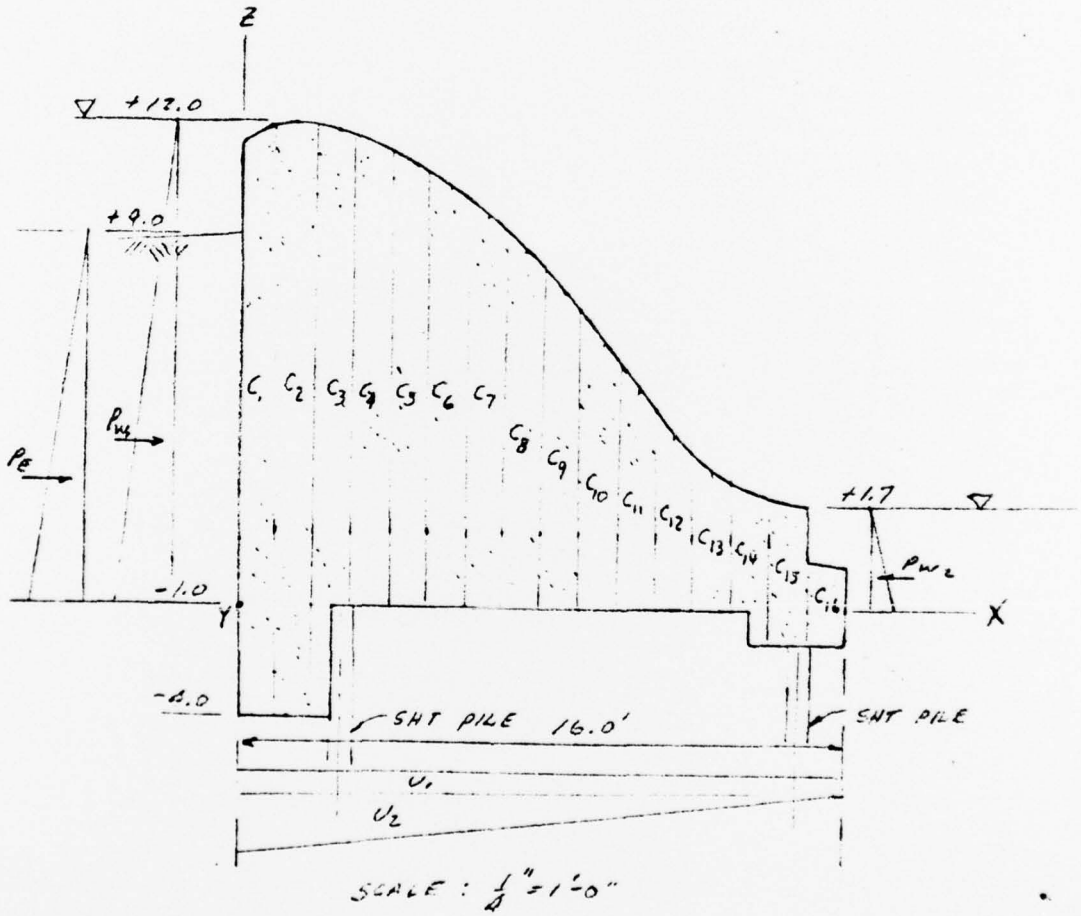
1. GRAVITY DAM DESIGN EM 1110-2-2200 SEP 58
2. GRAVITY DAM DESIGN STABILITY ETL 1110-2-184 FEB 74
3. RETAINING WALLS EM 1110-2-2502 MAY 61

LOAD CONDITION

HEADWATER TO CREST OF DAM (+12.0). TAILWATER (+1.7). FULL UPLIFT. SUBMERGED EARTH.

BY R.S.B. DATE 4 JAN 78 SUBJECT SILVER LAKE DAM SHEET NO. 2 OF .....
CHKD. BY ..... DATE ..... DAM INSPECTION JOB NO. .....

STABILITY



SCALE : $\frac{1}{4}$" = 1'-0"

NADP FORM
MAY 7- 1697 (TEMPORARY)

STACILITY

BY R.G.B. DATE 4/JAN/78 SUBJECT SILVER LAKE DAM
CHKD BY ..... DATE ..... DAM IN SPECTION
SHEET NO. 3 OF
JOB NO.

ITEM	DESCRIPTION	V	H_x	H_y	X	Y	Z	M_y	M_x
C_1	0.150 (15.8)	2.4			0.5			1.2	
C_2	0.150 (15.0)	2.4			1.5			3.6	
C_3	0.150 (14.3)	2.1			2.5			5.4	
C_4	0.150 (12.4)	1.9			3.5			6.5	
C_5	0.150 (11.9)	1.8			4.5			8.0	
C_6	0.150 (11.3)	1.7			5.5			9.3	
C_7	0.150 (10.5)	1.6			6.5			10.2	
C_8	0.150 (9.6)	1.4			7.5			10.8	
C_9	0.150 (8.5)	1.3			8.5			10.8	
C_{10}	0.150 (7.2)	1.1			9.5			10.3	
C_{11}	0.150 (5.9)	0.9			10.5			9.3	
C_{12}	0.150 (4.7)	0.7			11.5			8.1	
C_{13}	0.150 (3.7)	0.6			12.5			6.9	
C_{14}	0.150 (3.7)	0.6			13.5			7.5	
C_{15}	0.150 (3.8)	0.6			14.5			8.3	
C_{16}	0.150 (2.2)	0.3			15.5			5.1	
	SUB-TOTAL 1	21.4						121.3	
P_{W1}	$(13.0)^2(0.0625)(\frac{1}{2})$		5.3				4.3	22.7	
P_{W2}	$(2.7)^2(0.0625)(\frac{1}{2})$		-0.2				0.9	-0.2	
	SUB-TOTAL 2		5.1					22.5	
P_E	$(10.0)^2(0.0575)(0.3)(\frac{1}{2})$		0.9				3.3	2.8	
U_1	2.7(0.0625)(16.0)	-2.7			8.0			-21.6	
U_2	10.3(0.0625)(16.0)$(\frac{1}{2})$	-5.2			5.3			-27.3	
	SUB-TOTAL 3	-7.9						-48.9	
	TOTAL	13.5	6.0					97.7	

F-4

DATE 5 JAN 78 SUBJECT SILVER LAKE DAM SHEET NO. 4 OF
DATE DAM INSPECTION JOB NO.

STABILITY

$$\bar{X} = \frac{\Sigma M_{+}}{\Sigma V} = \frac{97.7}{13.5} = 7.24' > 5.33' \quad O.K.$$

$$K = \Sigma V \tan \phi = 13.5 (0.05) = 8.8\ K$$

$$S_{s-f} = \frac{R}{H} = \frac{8.8}{6.0} = 1.5 \quad O.K.$$

MAX. BASE PRESSURE

$$P = \frac{\Sigma V}{A}\left(1 + \frac{6e}{Z}\right) = \frac{13.5}{16.0}\left[1 + \frac{6(0.76)}{16.0}\right]$$

$$P = 1.1\ KSF$$

MAX FOUNDATION PRESSURE

$$P = 1.1 + 13.0(0.0625) = 1.9\ KSF < 2\ KSF \quad O.K.$$

SILVER LAKE DAM

DOVER, DELAWARE

APPENDIX F

PUBLIC LAW 92-367

Public Law 92-367
92nd Congress, H. R. 15951
August 8, 1972

An Act

To authorize the Secretary of the Army to undertake a national program of inspection of dams.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the term "dam" as used in this Act means any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation or (2) has an impounding capacity at maximum water storage elevation of fifty acre-feet or more. This Act does not apply to any such barrier which is not in excess of six feet in height, regardless of storage capacity or which has a storage capacity at maximum water storage elevation not in excess of fifteen acre-feet, regardless of height.

National dam inspection program.
"Dam."

SEC. 2. As soon as practicable, the Secretary of the Army, acting through the Chief of Engineers, shall carry out a national program of inspection of dams for the purpose of protecting human life and property. All dams in the United States shall be inspected by the Secretary except (1) dams under the jurisdiction of the Bureau of Reclamation, the Tennessee Valley Authority, or the International Boundary and Water Commission, (2) dams which have been constructed pursuant to licenses issued under the authority of the Federal Power Act, (3) dams which have been inspected within the twelve-month period immediately prior to the enactment of this Act by a State agency and which the Governor of such State requests be excluded from inspection, and (4) dams which the Secretary of the Army determines do not pose any threat to human life or property. The Secretary may inspect dams which have been licensed under the Federal Power Act upon request of the Federal Power Commission and dams under the jurisdiction of the International Boundary and Water Commission upon request of such Commission.

Army, authorization.
Exceptions.
41 Stat. 1063; 49 Stat. 863. 16 USC 791a.
86 STAT. 506
86 STAT. 507

SEC. 3. As soon as practicable after inspection of a dam, the Secretary shall notify the Governor of the State in which such dam is located the results of such investigation. The Secretary shall immediately notify the Governor of any hazardous conditions found during an inspection. The Secretary shall provide advice to the Governor, upon request, relating to timely remedial measures necessary to mitigate or obviate any hazardous conditions found during an inspection.

Notice to Governors.

SEC. 4. For the purpose of determining whether a dam (including the waters impounded by such dam) constitutes a danger to human life or property, the Secretary shall take into consideration the possibility that the dam might be endangered by overtopping, seepage, settlement, erosion, sediment, cracking, earth movement, earthquakes, failure of bulkheads, flashboard, gates on conduits, or other conditions which exist or which might occur in any area in the vicinity of the dam.

SEC. 5. The Secretary shall report to the Congress on or before July 1, 1974, on his activities under the Act, which report shall include, but not be limited to—

Report to Congress.

(1) an inventory of all dams located in the United States;

(2) a review of each inspection made, the recommendations furnished to the Governor of the State in which such dam is located and information as to the implementation of such recommendation;

(3) recommendations for a comprehensive national program for the inspection, and regulation for safety purpose of dams of the Nation, and the respective responsibilities which should be assumed by Federal, State, and local governments and by public and private interests.

Liability.

SEC. 6. Nothing contained in this Act and no action or failure to act under this Act shall be construed (1) to create any liability in the United States or its officers or employees for the recovery of damages caused by such action or failure to act; or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

Approved August 8, 1972.

LEGISLATIVE HISTORY:

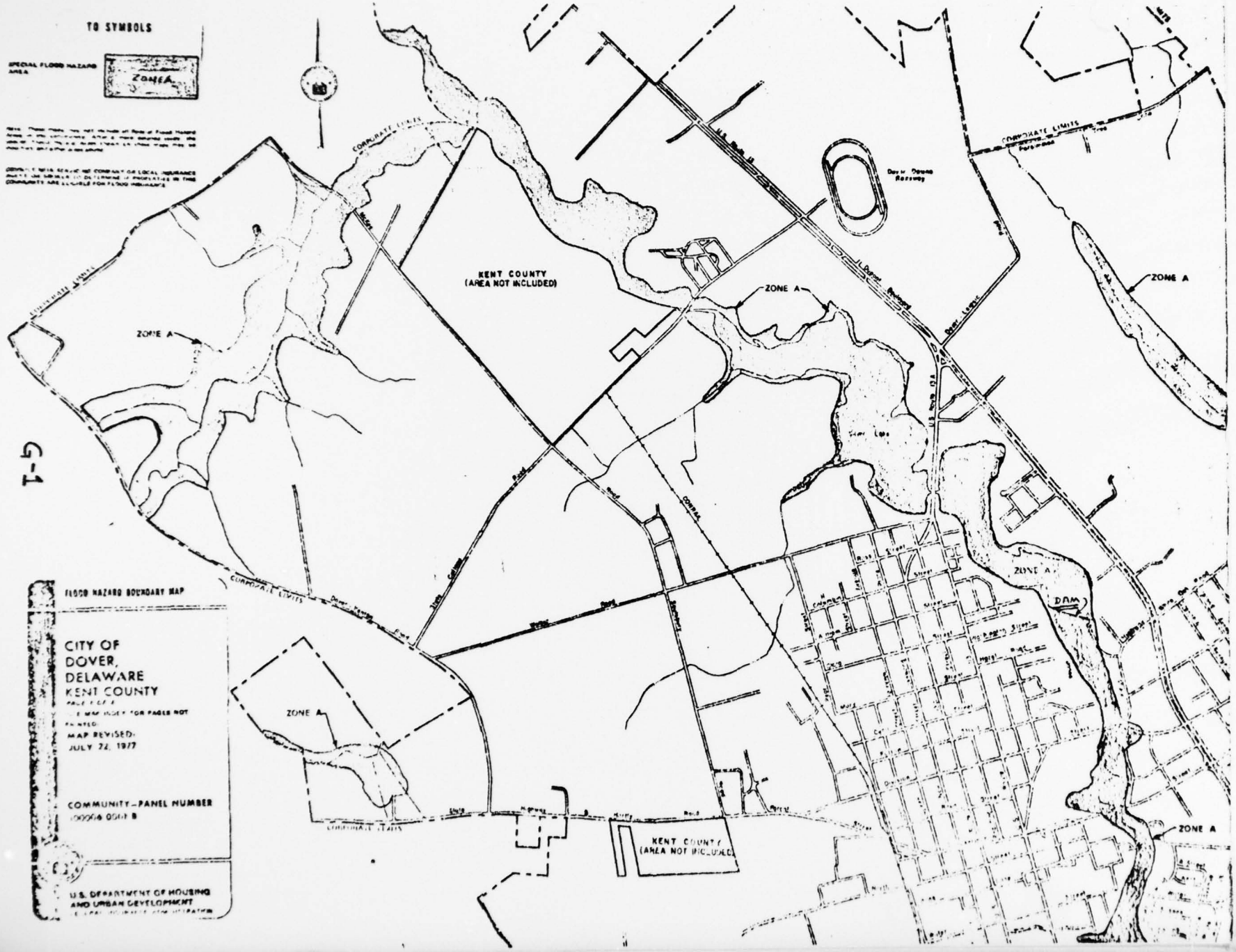
HOUSE REPORT No. 92-1232 (Comm. on Public Works).
CONGRESSIONAL RECORD, Vol. 118 (1972):
July 24, considered and passed House.
July 25, considered and passed Senate.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 8, No. 33:
Aug. 9, Presidential statement.

SILVER LAKE DAM

DOVER, DELAWARE

APPENDIX G

FLOOD HAZARD BOUNDARY MAP


TO SYMBOLS
SPECIAL FLOOD HAZARD AREA
ZONE A
KENT COUNTY (AREA NOT INCLUDED)
ZONE A
ZONE A
ZONE A
ZONE A
ZONE A
ZONE A
KENT COUNTY (AREA NOT INCLUDED)
CORPORATE LIMITS
FLOOD HAZARD BOUNDARY MAP
CITY OF DOVER, DELAWARE
KENT COUNTY
MAP REVISED: JULY 22, 1977
COMMUNITY-PANEL NUMBER
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

G-1